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Unit 1: Crop Ecology and Geography

Principles of crop ecology; Ecosystem concept; Productivity of ecosystem; Physiological limits of crop yield and variability in relation to ecological optima; Crop adaptation; Climate shift and its ecological implication; Greenhouse effect; Agro-ecological and agro climatic regions of India; Geographical distribution of cereals, legumes, oilseeds, vegetables, fodders and forages, commercial crops, condiments and spices, medicinal and aromatic plants; Adverse climatic factors and crop productivity; Photosynthesis, respiration, net assimilation, solar energy conversion efficiency and relative water content, light intensity. Water and CO_2 in relation to photosynthetic rates and efficiency; Physiological stress in crops; remote sensing: Spectral indices and their application in agriculture, crop water stress indices and crop stress detection.

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Unit 2: Weed Management

Scope and principles of weed management; Weeds classification, biology, ecology andallelopathy; Crop weed competition, weed threshold; Herbicides classification, formulations, mode of action, selectivity and resistance; Persistent of herbicides in soils and plants; Application methods and equipment; Biological weed control, bio- herbicides: Integrated weed management; recent development in weed management; Special weeds, parasitic and aquatic weeds and their management in cropped and non-cropped lands; weed shifts incropping systems; weed control schedules in field crops, vegetables and plantation crops; Role of GM crops in weed management; cost: benefit analysis of weed management.

Unit 3: Soil Fertility and Fertilizer Use

History of soil fertility and fertilizer use; Concept of essentiality of plant nutrients, their critical concentrations in plants, functions and deficiency symptoms, nutrient interactions, diagnostic techniques with special emphasis on emerging deficiencies of secondary and micro-nutrients; Soil fertility and productivity and their indicators; features of good soil management; Fertilizer materials including liquid fertilizers, their composition, mineralization, availability and reaction products in soils; Water solubility of phosphate fertilizers; Slow release fertilizers, nitrification inhibitors and their use for crop production; Principles and methods of fertilizer application; Integrated nutrient management; Agronomic and physiological efficiency and recovery of applied plant nutrients; criteria for determining fertilizer schedules for cropping systems, direct, residual and cumulative effects, Fertilizer related environmental problems including ground water pollution; Site-specific nutrient management; Contamination of heavy metals in peri-urban soils and their remediation.

Unit 4: Dryland Agronomy

Concept of dryland farming; dryland farming vs rainfed farming; History, development,significance and constraints of dryland agriculture in India; Climatic classification and delineation of dryland tracts; Characterization of agro-climatic environments of drylands; Rainfall analysis and length of growing season; Types of drought, drought syndrome, effect on plant growth, drought resistance, drought avoidance, drought management; Crop Planning including contingency, crop diversification, varieties, cropping systems, conservationcropping and mid-season corrections for aberrant weather conditions; Techniques of moisture conservation in-situ to reduce evapotranspiration, runoff and to increase infiltration; rain water harvesting and recycling concept, techniques and practices; Timeline and precision key factors for timely sowing, precision in seeding, weed control; Fertilizer placement, top dressing and foliar application, aqua-fertigation; Concept and importance of watershed management in dryland areas.

Unit 5: Crop Production in Problem Soils

Problem soils in india. Response of crop to acidity, salinity, sodicity, excess water and nutrient imbalances; Reclamation of problem soils, role of amendments, and drainage, Crop production techniques in problem soils - crops, varieties, cropping system and agronomic practices.

Unit 6: Crop Production

Crop production techniques for cereals, millets, pulses, oilseeds, fiber crops, sugar crops, fodder & pasture crops, medicinal, aromatic & under-utilized crops and agro-forestry system including origin, history, distribution, adaptation, climate, soil, season, improved varieties, fertilizer requirements, intercultural operations, water requirement. weed control, quality components, industrial use, economics and post-harvest technology.

Unit 7: Agricultural Statistics
Frequency distribution, standard error and deviation, correlation and regression analyses, co-efficient of variation; Tests of significance-t, F and chi-square (X2); Data transformation and missing plot techniques, Design of experiments and their basic principles, completely randomized, randomized block, split plot, strip-plot, factorial and simple confounding designs; Efficiency of designs; Method of statistical analysis for cropping systems including intercropping; Pooled analysis.

Unit 8: Sustainable Land Use Systems
Concept of sustainability; Sustainability parameters and indicator; Conservation agriculture (CA); climate change mitigation; Alternate land use systems; Types, extent and causes of wasteland; Shifting cultivation; Agroforestry, concept and importance, agro forestry systems; Agrostology, grassland ecology, problems and management of grassland; Agricultural and agro-industrial residues and its recycling, safe disposal; Allelopathy and biomass production; nutrient, water, weed, insect-pest and disease management in conservation agriculture; economic considerations in CA, adoption and constraints. Artificial intelligence: conceptsand application.

Unit 9: Basics of Soil and Water
Soil and water as vital resources for agricultural production; Soil-plant water relationship; Fate of rain water received at the soil surface, runoff and infiltration reciprocity, factors affecting infiltration, means to enhance in filterability of soil, mechanical and biological means to reduce runoff and soil loss; Water harvesting for crop life saving irrigations;watershed management; Soil and water conservation, Contingent crop plans and other strategies for aberrant weather indicator.

Unit 10: Soil Water Relationship
Soil water relations, water retention by soil, soil moisture *ch*aracteristics, field capacity, permanent wilting point, plant available water and exchangeable water, Soil irrigability, classification, factors affecting profile water storage, Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head; Movement of soil water saturated and unsaturated water flow; Field water budget, watergains and water losses from soil, deep percolation beyond root zone, capillary rise; Evapotranspiration (ET), scope for economizing water, measures for reducing direct evaporation from soil and crop canopies; Soil physical properties in relation to plant growth and development; Erodibility of soils and their prevention.

Unit 11: Plant Water Relationship
Plant water relations: Concept of plant water potential, cell water relations, plant water potential and its components; Significance of osmotic adjustment, leaf diffusive resistance, canopy temperature, canopy temperature depression (CTD); Water movement through soil - plant atmosphere systems, uptake and transport of water by roots; Development of crop water deficit, crop adaptation to water deficit, morpho- physiological effect of water deficit; Drought tolerance, mechanisms of drought tolerance, potential drought tolerance traits and their measurements

Unit 12: Irrigation Water Management
Management of irrigation water; History of irrigation in India; major' irrigation projects in India; Water resources development; Crop water requirements; Concepts of irrigation scheduling, Different approaches of irrigation scheduling; Soil water depletion plant indices and climatic parameters; Concept of critical stages of crop growth in relation to watersupplies; Methods of irrigation, merits and demerits of various methods; Measurement of irrigation water, application and distribution efficiencies; Management of water resources (rain, canal and ground water) for agricultural production; Irrigation legislation; Water quality, conjunctive use of water, irrigation strategies under different situation of wateravailability, Socio-economic aspects of on-farm water management; Irrigation water distribution; interaction between irrigation and fertilizers.

Unit 13: Management of Problematic Soils and Water
Problem soils and their distribution in India; Salt-affected, acidic water logged soils; Ground water resources, water quality criteria and use of brakish waters in agriculture; Excess saltand salt tolerant crops; Hydrological imbalances and their corrective measures; Concept of critical water

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table depths for crop growth; Contribution of shallow water table to crop water requirements; Management strategies for flood prone areas crop and crop calendar for flood affected areas; Drainage for improving water logged soils for crop production; Crop production and alternate use of problematic soils and poor quality water for agricultural and fish production; Management of problematic soils, role of amendments, and drainage.

Unit 14: Organic Farming

Organic farming: concept, definitions, components and types, its relevance to India and global agriculture and future prospects; Principles of organic farming; Organics and farming standards; Organic farming and sustainable agriculture; Management practices in organic farming; Selection and conversion of land, soil and water management; Soil fertility, components of organic nutrient management, ITKs and farmers' innovations in nutrientmanagement; Water and fertilizer use efficiency; Nutrient recycling; Organic manures; Soil biota; Bio-fertilizers and biogas technology; Integrated organic farming systems; Multiple andrelay cropping systems; Consumers' concerns on food quality and safety; Weeds, diseases and insect pest management; Socio-economic impacts; Marketing and export potential: Organic certification, standard and regulations; Principles and practices responsible for lossesof organic agricultural produce; Spiritual values and ethics.

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CHAPTER 01
Crop Ecology and Geography

2019

1. Which of the following best defines autecology in the context of agricultural ecosystems?
(A) The study of interactions between multiple species within a defined crop community
(B) The study of an individual crop species and its specific interaction with the environment
(C) The mapping of energy flow pathways across different agricultural zones
(D) The analysis of global biogeochemical cycles affecting regional agriculture

2025

2. Synecology within an agro-ecosystem primarily focuses on which of the following?
(A) The physiological adaptation of a single cultivar to drought
(B) The genetic mapping of a specific medicinal plant
(C) The calculation of photosynthetically active radiation for isolated leaves
(D) The complex interactions among crop populations, weeds, and soil microbiota

2006

3. Which of the following is classified as a primary abiotic component influencing an agricultural ecosystem?
(A) Photosynthetically active radiation
(B) Pathogenic fungi
(C) Soil organic carbon pools
(D) Nitrogen-fixing bacteria

2012

4. How do basic biotic components typically interact with abiotic variables in a dynamic agro-ecosystem?
(A) Biotic factors remain static while abiotic factors fluctuate seasonally
(B) Abiotic factors are regulated solely by anthropogenic interventions independently of biota
(C) Biotic components modify the microclimate, altering localized abiotic conditions
(D) Biotic elements function independently of soil nutrient availability

2011

5. In energy flow models of agro-ecosystems, the first trophic level is exclusively occupied by which functional group?
(A) Photoautotrophs
(B) Primary consumers
(C) Secondary consumers
(D) Decomposers

2009

6. According to the ecological ten percent law, if a crop canopy assimilates 10,000 kilocalories of solar energy, approximately how much energy is available to primary herbivores?
(A) 10,000 kilocalories
(B) 1,000 kilocalories
(C) 100 kilocalories
(D) 10 kilocalories

2021

7. The primary reason energy transfer between trophic levels is highly inefficient in agro-ecosystems is due to the loss of energy through which biological process?
(A) Chlorophyll photosynthesis
(B) Cellular respiration
(C) Stomatal transpiration
(D) Osmotic adjustment

2006

8. Consider the following statements regarding energy flow in agricultural ecosystems:
I. Energy flow is strictly bidirectional.
II. Energy flow follows the principles of thermodynamics.
III. Energy dissipates as heat at each trophic level.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2010

9. Lindeman's trophic dynamic concept models ecological systems primarily on the basis of which metric?
(A) Interspecific genetic diversity

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(B) Plant morphological adaptations
(C) Canopy water use efficiency
(D) Energy transfer efficiency

2013

10. Which statement INCORRECTLY characterizes the universal energy flow model proposed by Odum?
(A) It includes a feedback loop for recycled energy
(B) It applies to both individual organisms and entire ecosystems
(C) It demonstrates that energy decreases with each successive transfer
(D) It accounts for energy channeled into detritus pathways

2007

11. Gross Primary Productivity (GPP) in a crop ecosystem is strictly defined as the total amount of what parameter?
(A) Carbon incorporated into usable agricultural yield
(B) Total organic matter synthesized by producers
(C) Dry biomass remaining after autotrophic respiration
(D) Total solar radiation reaching the canopy surface

2013

12. Net Primary Productivity (NPP) is mathematically expressed by which relationship, where R represents autotrophic respiration?
(A) $NPP = GPP + R$
(B) $NPP = GPP - R$
(C) $NPP = GPP \times R$
(D) $NPP = \frac{GPP}{R}$

2010

13. Which micrometeorological technique is most accurately used to measure net ecosystem CO_2 exchange continuously over a crop field?
(A) Eddy covariance technique
(B) Gravimetric soil moisture sampling
(C) Infrared thermometry
(D) Canopy leaf area index profiling

2007

14. What causes the significant difference between GPP and NPP in mature agricultural crops?
(A) Insufficient levels of incoming solar radiation
(B) Elevated stomatal resistance across the canopy
(C) Photorespiration and dark respiratory losses
(D) Excessive transpiration and stomatal water loss

2015

15. The harvest index of an agricultural crop is directly related to NPP by representing which specific fraction?
(A) The ratio of GPP to autotrophic respiration
(B) The ratio of net assimilation rate to leaf area
(C) The ratio of root biomass to total shoot biomass
(D) The ratio of economic yield to biological yield

2016

16. Consider the following statements regarding ecological principles in agriculture:
I. Liebig's Law focuses on the factor present in the most abundant supply.
II. Shelford's Law states that only minimum limits determine organism success.
III. Ecological optima represent conditions where crop growth is minimized.
IV. Limiting factors can act synergistically.
Which of the above statements are INCORRECT?
(A) I, II and III
(B) II, III and IV
(C) I, II and IV
(D) I, III and IV

2015

17. Liebig's Law of the Minimum asserts that plant growth is dictated not by total resources available, but by the resource that is in what state?
(A) Highest abundance
(B) Scarcest supply relative to plant needs
(C) Most accessible to root systems
(D) Least variable over the growing season

2001

18. Shelford's Law of Tolerance expands upon previous ecological theories by introducing which critical concept?
(A) Organisms are restricted solely by critical soil nutrient deficiency
(B) Water availability serves as the only limiting environmental factor
(C) Ambient temperature regulates crop development without an upper limit
(D) Organisms possess specific minimum, optimum, and maximum tolerances

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2016

19. A crop cultivar exhibiting a wide range of tolerance to varying soil pH levels is best described by which ecological term?
(A) Euryecious
(B) Stenohaline
(C) Stenothermal
(D) Oligotrophic

2007

20. Arrange the following components in the correct sequence of their interaction in an agro-ecosystem trophic model.
1. Primary Producers
2. Solar Radiation
3. Secondary Consumers
4. Primary Consumers
(A) 2, 1, 4, 3
(B) 1, 2, 3, 4
(C) 2, 4, 1, 3
(D) 4, 3, 1, 2

2024

21. Which morphological adaptation helps arid zone crops reduce excessive water loss through transpiration?
(A) Dense leaf pubescence
(B) Broad and thin leaf laminas
(C) Increased stomatal density
(D) Shallow and highly branched fibrous roots

2006

22. The development of aerenchyma tissue in roots is a classic anatomical adaptation to which specific environmental stress?
(A) High soil salinity
(B) Severe drought
(C) Frost and sub-zero temperatures
(D) Soil waterlogging and hypoxia

2014

23. Proline accumulation in crop leaves primarily serves what physiological function under severe water deficit?
(A) Enhancing structural rigidity of the cell wall
(B) Acting as an osmoprotectant to maintain turgor
(C) Accelerating the degradation of foliar chlorophyll
(D) Mechanically blocking stomatal pores to limit loss

2004

24. Consider the following statements concerning greenhouse gases and global warming potential (GWP):
I. Carbon dioxide has a GWP of exactly 1.
II. Methane has a lower GWP than carbon dioxide.
III. Nitrous oxide is primarily emitted from synthetic fertilizers.
IV. Enteric fermentation is a major source of methane.
V. Water vapor is the most potent anthropogenic greenhouse gas.
Which of the above statements are correct?
(A) I, II, III and IV
(B) I, III, IV and V
(C) I, III and IV
(D) II, IV and V

2007

25. Which agricultural practice is the most significant anthropogenic contributor to global nitrous oxide (N_2O) emissions?
(A) Flooding paddy fields for wet rice cultivation
(B) Burning harvested agricultural crop residues
(C) Operating diesel-powered agricultural machinery
(D) Applying synthetic nitrogen-based fertilizers

2016

26. The high Global Warming Potential (GWP) of nitrous oxide relative to carbon dioxide is primarily due to what atmospheric characteristic?
(A) Its high infrared absorption and long atmospheric lifetime
(B) Its elevated concentration levels within the lower troposphere
(C) Its rapid chemical degradation into ozone-depleting substances
(D) Its unique physical ability to generate dense agricultural smog

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2019

27. Climate shift typically impacts crop phenology by causing which measurable physiological change in temperate regions?
(A) Delayed vegetative emergence of crops during spring
(B) Earlier anthesis and a shorter grain-filling period
(C) Extended duration of the total physiological maturity phase
(D) Complete suppression of the reproductive developmental phase

2024

28. Growing Degree Days (GDD) are calculated to predict crop developmental stages using which mathematical formulation?

(A) $GDD = (T_{\max} - T_{\min}) \times T_{base}$

(B) $GDD = \frac{(T_{\max} + T_{\min})}{2} - T_{base}$

(C) $GDD = \frac{(T_{\max} - T_{base})}{2}$

(D) $GDD = \frac{(T_{\max} + T_{\min})}{T_{base}}$

2008

29. Geographical shifts due to climate change generally force the optimal cultivation zones for cool-season crops to move in which direction?
(A) Toward lower latitudes and lower altitudes
(B) Toward higher latitudes and higher altitudes
(C) Toward equatorial tropical zones
(D) Toward coastal plains regardless of latitude

2004

30. The Planning Commission of India initially divided the country into how many broad Agro-climatic zones for agricultural planning?
(A) 10
(B) 15
(C) 20
(D) 25

2023

31. The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) delineated 20 Agro-ecological zones based fundamentally on which primary criteria?
(A) National political boundaries and regional water availability
(B) Local terrain topography and regional market economic demands
(C) Historical crop yield productivity data and pesticide usage
(D) Agro-bioclimate, length of growing period, and soilscape

2024

32. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The Trans-Gangetic Plain region is characterized by high agricultural productivity and intensive irrigation.
Reason (R): This zone receives the highest annual natural rainfall in India, negating the need for groundwater extraction.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

33. The concept of "Centers of Origin" for cultivated plants, identifying regions of high genetic diversity, was originally proposed by which scientist?
(A) Norman Borlaug
(B) Nikolai Vavilov
(C) Gregor Mendel
(D) Charles Darwin

2014

34. According to Vavilovian classification, which geographical region is recognized as the primary center of origin for maize (Zea mays)?
(A) Central Asia
(B) Near East
(C) South America
(D) Mesoamerica

2009

35. The geographical distribution of crops is most strictly constrained on a global scale by which interacting abiotic factors?
(A) Temperature regimes and precipitation patterns
(B) Ambient wind speed and atmospheric pressure
(C) Total soil profile depth and bulk density
(D) Soil microbial diversity and earthworm activity

2004

36. Which cereal crop is uniquely adapted to prolonged field inundation due to specialized aerenchyma tissues?
(A) Zea mays
(B) Triticum aestivum
(C) Oryza sativa
(D) Sorghum bicolor

2010

37. Pearl millet (Pennisetum glaucum) is predominantly distributed in northwestern India due to its exceptional tolerance to which condition?
(A) Drought and high ambient temperatures
(B) High rainfall and soil waterlogging
(C) Acidic soils and aluminum toxicity
(D) Freezing temperatures and winter frost

2005

38. Chickpea cultivation in India is largely restricted to the rabi (winter) season because the crop requires which specific climatic conditions?

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(A) High relative humidity and heavy rainfall during flowering
(B) Continuous high ambient temperatures exceeding 35 degrees C
(C) Short photoperiods combined with extensive monsoon flooding
(D) Cool, dry winters followed by a warm ripening period

2011

39. Which medicinal plant is highly specialized to the unique cold and arid ecological niche of the high-altitude Himalayan regions?
(A) Ashwagandha (Withania somnifera)
(B) Saffron (Crocus sativus)
(C) Senna (Cassia angustifolia)
(D) Isabgol (Plantago ovata)

2021

40. Match the crops in List I with their predominant climatic distribution requirements in List II.
List I: (Crops)
P. Black pepper
Q. Mustard
R. Groundnut
S. Sorghum
List II: (Climatic Distribution Requirements)
1. Semi-arid, warm, well-drained soils
2. Cool, subtropical winter, frost susceptible
3. Hot, humid, high rainfall tropical regions
4. Warm, semi-arid, high drought tolerance
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-2, S-3

2019

41. Frost damage in susceptible agricultural crops is primarily caused by which cellular event?
(A) Rapid degradation of chlorophyll molecules
(B) Extreme stomatal opening and desiccation
(C) Severe depletion of root carbon reserves
(D) Intracellular ice crystal formation

2017

42. High temperature stress during the anthesis stage of wheat typically results in significant yield reduction due to what mechanism?
(A) Pollen sterility and reduced grain setting
(B) Enhanced root respiration
(C) Premature germination of seeds in the spike
(D) Excessive tillering

2010

43. Cyclonic storms uniquely devastate mature standing crops through which primary physical mechanism?
(A) Induction of systemic viral infections
(B) Mechanical lodging and grain shattering
(C) Sudden onset of permanent crop wilting
(D) Destruction of soil symbiotic bacteria

2022

44. Photosynthetically Active Radiation (PAR) is defined by which specific spectral wavelength range?
(A) 200 to 400 nm
(B) 400 to 700 nm
(C) 700 to 1000 nm
(D) 1000 to 1400 nm

2001

45. The Leaf Area Index (LAI) of a crop canopy represents the ratio of which two parameters?
(A) Total leaf area to ground surface area
(B) Total leaf biomass to total root biomass
(C) Total photosynthetic rate to respiration rate
(D) Average leaf length to average leaf width

2018

46. The attenuation of solar radiation as it penetrates downward through a crop canopy is most accurately described by which scientific principle?
(A) Liebig's Law
(B) Shelford's Law
(C) The Beer-Lambert Law
(D) The Stefan-Boltzmann Law

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2013

47. In the context of canopy architecture, an extinction coefficient (k) value closer to 1.0 indicates which structural feature?
(A) Highly vertical leaves allowing deep light penetration
(B) Complete absence of foliage in the upper canopy layers
(C) Perfectly transparent leaves reducing light absorption
(D) Highly horizontal leaves intercepting top canopy light

2007

48. Select the correct order of increasing Global Warming Potential (GWP) over a 100-year time horizon for the following agricultural greenhouse gases.
(A) Carbon dioxide $<$ Methane $<$ Nitrous oxide
(B) Methane $<$ Carbon dioxide $<$ Nitrous oxide

(C) Nitrous oxide < Methane < Carbon dioxide
(D) Carbon dioxide < Nitrous oxide < Methane

2023
49. The light compensation point is reached when the rate of photosynthesis exactly equals the rate of which physiological process?
(A) Active photorespiration
(B) Cellular respiration
(C) Cuticular transpiration
(D) Root nutrient absorption

2004
50. Which crop type typically exhibits the highest light saturation point, continuing to increase photosynthetic rates under intense solar radiation?
(A) C_3 crops like wheat
(B) Shade-tolerant crops
(C) CAM crops like pineapple
(D) C_4 crops like maize

2016
51. The CO_2 compensation point is significantly lower in C_4 plants compared to C_3 plants primarily due to the action of which enzyme?
(A) PEP carboxylase
(B) RuBisCO enzyme
(C) Malate dehydrogenase
(D) ATP synthase enzyme

2004
52. Which anatomical feature is uniquely required for the standard C_4 photosynthetic pathway to function efficiently?
(A) Mesophyll dominance
(B) Sunken stomata
(C) Kranz anatomy
(D) Reduced cuticles

2011
53. The fundamental biochemical difference distinguishing CAM plants from C_3 and C_4 plants is the separation of initial CO_2 fixation and the Calvin cycle by what dimension?
(A) Temporal separation between day and night
(B) Spatial separation between different cell types
(C) Temperature gradients across the leaf
(D) Enzymatic separation within the mitochondria

2025
54. Why does photorespiration significantly reduce the Net Assimilation Rate (NAR) in C_3 crops under hot, dry conditions?
(A) Stomata close fully, leading to lethal crop desiccation
(B) Dark respiration plummets, halting metabolic production
(C) The plant switches to the CAM pathway very inefficiently
(D) RuBisCO acts as an oxygenase, releasing fixed CO_2

2023
55. Dark respiration is essential for crop survival and growth because it serves what primary biochemical purpose?
(A) It generates essential oxygen within root systems
(B) It provides ATP and carbon skeletons for growth
(C) It converts stored light energy into chemical ATP
(D) It actively pumps excess water out of plant roots

2024
56. Arrange the following plant groups in correct descending order based on their typical maximum theoretical water-use efficiency (WUE).
1. C_3 crops
2. CAM crops
3. C_4 crops
(A) 2, 3, 1
(B) 1, 3, 2
(C) 3, 2, 1
(D) 2, 1, 3

2012
57. The maximum theoretical solar energy conversion efficiency for terrestrial C_3 crops is thermodynamically limited to approximately what percentage?
(A) 1–2%
(B) 4–6%
(C) 15–20%
(D) 30–35%

2005
58. Relative Water Content (RWC) is a preferred metric for assessing crop water status. It is calculated using which formula?
(A) $RWC = \frac{(\text{Fresh Weight} - \text{Dry Weight})}{(\text{Turgid Weight} - \text{Dry Weight})} \times 100$
(B) $RWC = \frac{(\text{Turgid Weight} - \text{Fresh Weight})}{\text{Dry Weight}} \times 100$
(C) $RWC = \frac{(\text{Fresh Weight} - \text{Turgid Weight})}{(\text{Fresh Weight} - \text{Dry Weight})} \times 100$
(D) $RWC = \frac{\text{Dry Weight}}{\text{Fresh Weight}} \times 100$

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2007

59. Elevated atmospheric CO_2 concentrations typically affect stomatal conductance in C_3 and C_4 crops in what manner?
(A) Induces permanent stomatal opening across leaves
(B) Decreases conductance and reduces transpiration
(C) Increases stomatal density per unit of leaf area
(D) Has no measurable effect on guard cell dynamics

2014

60. How does the Free-Air CO_2 Enrichment (FACE) technique provide an advantage over greenhouse experiments for studying crop responses?
(A) It allows precise, multi-tier control of field soil moisture
(B) It evaluates crop responses in natural, open-field conditions
(C) It isolates experimental plants from localized pest interactions
(D) It completely eliminates photorespiration in canopy leaves

2022

61. Crop Water-Use Efficiency (WUE) is best defined scientifically as the ratio between which two specific biological fluxes?
(A) Carbon assimilation to transpirational water loss
(B) Total seasonal rainfall received to final crop yield
(C) Total root water uptake to canopy leaf evaporation
(D) Soil water holding capacity to immediate plant turgor

2013

62. Which biochemical mechanism constitutes a plant's primary defense against Reactive Oxygen Species (ROS) generated during abiotic stress?
(A) Rapid physical closure of stomatal pores
(B) Accumulation of toxic ions within vacuoles
(C) Upregulation of cellular antioxidant enzymes
(D) Shedding of all old, mature crop leaves

2016

63. Drought tolerance in crop plants often involves osmotic adjustment, which is achieved by the intracellular accumulation of what type of compounds?
(A) Starch grains and structural polysaccharides
(B) Complex cell wall polymers like lignin and cellulose
(C) Lipid peroxides like malondialdehyde and peroxide
(D) Compatible solutes like proline and glycine betaine

NODIA

2015

64. Under soil salinity stress, crop plants experience an initial rapid growth reduction primarily due to which phenomenon?
(A) Ion-specific toxicity of chloride ions
(B) Ion-specific toxicity of sodium ions
(C) Osmotic effects reducing root water uptake
(D) Complete destruction of root cortex tissues

2021

65. The production of the phytohormone ethylene increases rapidly under waterlogged conditions, frequently triggering which morphological response?
(A) Deepening of the taproot system to access water
(B) Formation of adventitious roots and aerenchyma
(C) Extreme structural thickening of the leaf cuticle
(D) Rapid conversion to the CAM photosynthetic pathway

2015

66. Remote sensing in agriculture relies primarily on measuring the reflection and emission of which physical property from crop canopies?
(A) Reflected sound waves
(B) Ambient magnetic fields
(C) Local gravitational waves
(D) Electromagnetic waves

2015

67. Healthy, growing crop vegetation exhibits a distinct spectral signature characterized by which reflectance pattern?
(A) Low reflectance in the visible red band and high reflectance in the near-infrared band
(B) High reflectance in the visible red band and low reflectance in the near-infrared band
(C) Low reflectance in both the visible red and near-infrared bands of the spectrum
(D) High reflectance uniformly across all regions of the visible electromagnetic spectrum

2022

68. The Normalized Difference Vegetation Index (NDVI) is mathematically formulated using which specific spectral bands?
(A) $NDVI = \dfrac{(\text{Green} - \text{Blue})}{(\text{Green} + \text{Blue})}$

(B) $NDVI = \dfrac{(\text{Red} - \text{NIR})}{(\text{Red} + \text{NIR})}$

(C) $NDVI = \dfrac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$

(D) $NDVI = \dfrac{(\text{SWIR} - \text{NIR})}{(\text{SWIR} + \text{NIR})}$

2016

69. The Soil Adjusted Vegetation Index (SAVI) introduces a canopy background adjustment factor (L) to correct for what specific issue in NDVI?
(A) Bare soil reflectance in sparse fields
(B) Atmospheric aerosol scattering errors
(C) Heavy cloud cover signal interference
(D) Satellite sensor degradation over time

2012

70. Infrared thermometry measures canopy temperature as an indicator of plant water stress based on the relationship between leaf temperature and what process?
(A) Photosynthesis
(B) Root respiration
(C) Mineral nutrient uptake
(D) Transpirational cooling

2007

71. The Crop Water Stress Index (CWSI) calculation requires the measurement of canopy temperature relative to which two baseline boundaries?
(A) Absolute zero and ambient air temperatures
(B) Fully transpiring and non-transpiring baselines
(C) Soil surface and atmospheric dew point temperatures
(D) Daytime maximum and nighttime minimum temperatures

2009

72. Consider the following statements concerning the measurement of Gross Primary Productivity (GPP) and Net Primary Productivity (NPP):
I. NPP can be directly estimated via sequential biomass harvesting.
II. GPP is always lower than NPP in healthy crop stands.
III. Eddy covariance measures the net exchange of carbon dioxide.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2019

73. Which environmental variable exerts the most dominant control over the progression of a crop through its phenological stages?
(A) Soil pH
(B) Wind velocity
(C) Soil organic matter content
(D) Ambient temperature

2009

74. Which of the following defines the "Base Temperature" (T_{base}) used in calculating thermal time or Growing Degree Days (GDD)?
(A) The threshold temperature below which crop development ceases
(B) The absolute lowest temperature recorded during the growing season
(C) The temperature at which the crop exhibits its maximum growth rate
(D) The average nightly temperature over the crop life cycle

2010

75. A prominent characteristic of Vavilovian centers of origin is the natural presence of which botanical elements?
(A) High density of modern genetically modified cultivars
(B) Wild relatives and genetic diversity of the crop
(C) Monocultures of the primary domesticated crop species
(D) Specific soil types uniquely suited to the regional crop

2004

76. In defining agro-climatic zones, the Length of Growing Period (LGP) is determined primarily by the interaction of which two meteorological parameters?
(A) Mean ambient temperature and regional wind speed
(B) Precipitation and potential evapotranspiration
(C) Relative air humidity and canopy photoperiod
(D) Total solar radiation and atmospheric pressure

2024

77. The "Law of Homologous Series in Variation," which aids in discovering new genetic traits in related crop species, was postulated by:
(A) Nikolai Vavilov
(B) Justus von Liebig
(C) V.E. Shelford

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(D) R.L. Lindeman

2006

78. Winter wheat requires exposure to prolonged periods of low temperatures to transition from the vegetative to the reproductive phase. This physiological requirement is known as:
(A) Photoperiodism
(B) Thermoperiodism
(C) Vernalization
(D) Stratification

2016

79. When elevated atmospheric CO_2 causes stomata to partially close, what is the direct immediate benefit to the crop plant?
(A) Increased entry of fungal pathogens into leaves
(B) Enhanced uptake and absorption of soil nitrogen
(C) Elevated canopy temperature for faster ripening
(D) Reduced transpiration and increased crop WUE

2005

80. Consider the following statements regarding C_3, C_4, and CAM pathways:
I. C_4 plants possess Kranz anatomy.
II. CAM plants open their stomata primarily at night.
III. C_3 plants suffer from higher rates of photorespiration than C_4 plants.
IV. C_4 plants fix CO_2 initially into a three-carbon acid.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2011

81. In an agricultural context, "Terminal Heat Stress" is most detrimental to wheat crops when it occurs during which specific developmental phase?
(A) Seedling emergence
(B) Grain filling
(C) Canopy tillering
(D) Root initiation

2024

82. Advection frost, which can severely damage standing crops, is uniquely characterized by which meteorological condition compared to radiation frost?
(A) It occurs on clear, calm nights via rapid radiative cooling
(B) It is easily mitigated by overhead sprinkler irrigation systems
(C) It strictly affects root zones while canopies remain warm
(D) It involves horizontal advection of cold air masses

2004

83. The specific heat capacity of water is utilized in which common agricultural strategy to protect high-value crops from radiation frost?
(A) Overhead sprinkler irrigation during freezing
(B) Applying high rates of synthetic nitrogen fertilizer
(C) Tilling soil deeply prior to the expected frost
(D) Applying chemical defoliants to crop canopies

2014

84. Which plant pigment complex acts as the primary receptor for measuring day length in photoperiod-sensitive agricultural crops?
(A) Chlorophyll a
(B) Anthocyanin
(C) Phytochrome
(D) Carotenoids

NODIA

2021

85. The process by which light energy absorbed by chlorophyll is dissipated safely as heat to prevent oxidative damage during high irradiance is termed:
(A) Non-photochemical quenching
(B) Photosynthetic phosphorylation
(C) Ribulose photorespiration
(D) Directional phototropism

2007

86. Which structural component of crop leaves acts to increase albedo, thereby reducing the heat load on the leaf under intense sunlight?
(A) Thick spongy mesophyll layer
(B) Dense palisade parenchyma cells
(C) Enlarged bundle sheath anatomy
(D) Epicuticular wax and trichomes

2003

87. Under severe drought stress, the synthesis and redistribution of which phytohormone induces rapid stomatal closure?
(A) Indole-3-acetic acid (IAA)
(B) Abscisic acid (ABA)
(C) Gibberellic acid (GA)
(D) Cytokinin

2024

88. Consider the following statements regarding abiotic stress markers in crops:

I. Malondialdehyde (MDA) content indicates the extent of lipid peroxidation.
II. Superoxide dismutase (SOD) decreases under severe oxidative stress.
III. Proline serves as a compatible osmolyte.
IV. Dehydrins accumulate to protect cellular proteins during desiccation.
V. Relative water content (RWC) increases as drought severity increases.

Which of the above statements are correct?
(A) I, III and IV
(B) II, III, IV and V
(C) I, II, III and IV
(D) I, IV and V

2016

89. Salinity stress in agricultural soils is chemically quantified by measuring which parameter of the soil saturation extract?
(A) Cation Exchange Capacity (CEC)
(B) Bulk density
(C) Organic carbon percentage
(D) Electrical Conductivity (EC)

2008

90. Which agricultural remote sensing platform offers the highest temporal resolution for monitoring rapidly developing crop water stress over a single field?
(A) Unmanned Aerial Vehicle (UAV / Drone)
(B) Sun-synchronous satellite (e.g., Landsat)
(C) Geostationary weather satellite
(D) High-altitude weather balloon

2018

91. Hyperspectral remote sensing differs from traditional multispectral remote sensing primarily in what technological capacity?
(A) It measures soil moisture parameters exclusively
(B) It records data in narrow, contiguous bands
(C) It utilizes acoustic sonar waves instead of light
(D) It provides coarser spatial resolution imagery

2013

92. The "Red Edge" in a vegetation spectral reflectance curve refers to the steep transition between which two regions of the electromagnetic spectrum?
(A) Ultraviolet and Blue
(B) Red and Near-Infrared
(C) Blue and Green
(D) Shortwave Infrared and Thermal Infrared

2001

93. At what LAI value does the canopy intercept roughly 95% of incident PAR, beyond which further leaf area does not significantly increase crop growth rate?
(A) Critical LAI
(B) Minimum LAI
(C) Optimal LAI
(D) Zero LAI

2009

94. The thermal infrared band of the electromagnetic spectrum used for computing Canopy Temperature Depression (CTD) lies approximately in which wavelength range?
(A) 0.4 to 0.7 μm
(B) 0.7 to 1.3 μm
(C) 1.5 to 3.0 μm
(D) 8.0 to 14.0 μm

2002

95. A negative Crop Temperature Depression (CTD) value (where canopy temperature is warmer than air temperature) generally indicates what physiological state?
(A) Optimal canopy photosynthesis rate
(B) Excessive transpirational cooling
(C) Severe foliar nitrogen deficiency
(D) Water stress and stomatal closure

2019

96. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The Net Assimilation Rate (NAR) of a crop typically decreases as the crop matures and leaf area index (LAI) reaches maximum values.
Reason (R): Mutual shading of lower leaves increases the proportion of respiratory tissues relative to photosynthetically active tissues.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2006

97. The quantum yield of photosynthesis is defined scientifically as:
(A) The number of ATP molecules produced per unit of glucose oxidized
(B) The moles of CO_2 fixed or O_2 evolved per

mole of photons absorbed
(C) The total biomass generated per liter of water transpired
(D) The ratio of GPP to dark respiration

2022
98. In C_4 plants, the spatial separation of initial CO_2 fixation and the Calvin cycle effectively eliminates photorespiration by achieving what local condition?
(A) An extremely acidic metabolic environment within mesophyll tissue
(B) Complete physical exclusion of oxygen from the inner leaf layers
(C) Chemical deactivation of the oxygenase function of the RuBisCO enzyme
(D) A high concentration of CO_2 around RuBisCO in bundle sheath cells

2017
99. The first stable carbon compound formed in the C_3 photosynthetic pathway is:
(A) 3-Phosphoglycerate (3-PGA)
(B) Oxaloacetate
(C) Malate
(D) Ribulose-1,5-bisphosphate (RuBP)

2024
100. During the initial osmotic phase of salinity stress, plants exhibit symptoms nearly identical to which other abiotic stress?
(A) Waterlogging hypoxia
(B) Boron toxicity
(C) Drought stress
(D) Freezing injury

2017
101. Which term describes a plant's strategy to complete its entire life cycle rapidly before the onset of seasonal drought?
(A) Drought escape
(B) Drought tolerance
(C) Drought avoidance
(D) Osmotic adjustment

2025
102. Halophytes survive in highly saline environments by employing which cellular mechanism to prevent specific ion toxicity in the cytoplasm?
(A) Rapid transpiration to dilute salts
(B) Complete cessation of root water uptake
(C) Conversion of sodium to micronutrients
(D) Sequestration of ions into vacuoles

2006
103. Submergence tolerance in specific rice cultivars (e.g., those carrying the Sub1A gene) is characterized by which survival strategy?
(A) Rapid stem elongation to escape deep floodwaters
(B) Quiescence, conserving energy until water recedes
(C) Metabolic conversion to CAM pathway under water
(D) Complete systemic abscission of all crop foliage

2011
104. Match the crop species in List I with their recognized Vavilovian centers of primary origin in List II.
List I: (Crop Species)
P. Potato (Solanum tuberosum)
Q. Soybean (Glycine max)
R. Sorghum (Sorghum bicolor)
S. Wheat (Triticum aestivum)
List II: (Centers of Origin)
1. Near East
2. South American (Andean)
3. Chinese
4. African
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-4, R-3, S-1
(D) P-1, Q-3, R-4, S-2

2010
105. In the measurement of crop canopy characteristics, an inversion of the Beer-Lambert Law using light transmission data is frequently used to indirectly estimate which parameter?
(A) Chlorophyll content
(B) Root length density
(C) Stomatal conductance
(D) Leaf Area Index (LAI)

2014
106. Which spectral index is designed to resist saturation at high biomass levels, making it superior to NDVI for monitoring dense crop canopies?
(A) Simple Ratio (SR)
(B) Soil Adjusted Vegetation Index (SAVI)
(C) Normalized Difference Water Index (NDWI)
(D) Enhanced Vegetation Index (EVI)

2008
107. The Normalized Difference Water Index (NDWI) is uniquely sensitive to changes in vegetation

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canopy water content because it incorporates which spectral band?
(A) Shortwave Infrared (SWIR)
(B) Ultraviolet-B (UV-B) radiation
(C) Visible blue spectral band
(D) Far-thermal infrared band

2009

108. Active remote sensing systems, unlike passive sensors, possess what critical capability for agricultural monitoring?
(A) Depend exclusively on solar illumination across passive reflective bands
(B) Generate internal energy to acquire data regardless of light or cloud cover
(C) Measure thermal emissions directly from the crop surface at night
(D) Utilize high-altitude platforms to achieve unlimited spatial resolution

2008

109. Which of the following greenhouse gases is exclusively anthropogenic and not produced naturally within agro-ecosystems?
(A) Biogenic methane gas (CH_4)
(B) Chlorofluorocarbons (CFCs)
(C) Soil-derived nitrous oxide (N_2O)
(D) Atmospheric carbon dioxide (CO_2)

2003

110. Which primary soil condition dictates the high methane emissions characteristic of lowland paddy cultivation?
(A) Anaerobic, highly reduced soil conditions
(B) Aerobic, highly oxidized soil conditions
(C) Strongly acidic soil pH levels below 4.0
(D) Elevated concentrations of soil nitrate ions

2014

111. Enteric fermentation, a major agricultural source of methane, is biologically mediated by which group of organisms in the rumen of livestock?
(A) Cellulolytic fungi populations
(B) Rumen-associated cyanobacteria
(C) Methanogenic archaea species
(D) Filamentous actinomycetes

2010

112. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Intercropping legumes with cereals is an ecological strategy to optimize resource use efficiency in agro-ecosystems.
Reason (R): Legumes and cereals occupy perfectly identical spatial and temporal ecological niches.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

113. The Western Himalayan Region (Zone 1) in India's agro-climatic zoning is primarily designated for the cultivation of which specific commodities?
(A) Heavy paddy, jute, and tropical oilseeds
(B) Irrigated cotton, sugarcane, and wheat
(C) Apples, saffron, and temperate vegetables
(D) Pearl millet, cluster bean, and sorghum

2021

114. The concept of "Ecological Niche" as applied to agricultural crops refers comprehensively to:
(A) The physical habitat and geographic coordinates where a crop species is cultivated
(B) The functional range of environmental conditions and resources a crop utilizes
(C) The theoretical maximum yield potential expressed by a specific crop cultivar
(D) The specific soil depth profile and root volume colonized by a mature crop

NODIA

2021

115. Which of the following is considered an INCORRECT pair of crop and its limiting geographical constraint?
(A) Sugarcane — Severe frost
(B) Tea — Waterlogged, stagnant soil
(C) Jute — Low rainfall and arid conditions
(D) Pearl millet — High temperatures

2019

116. A heat wave occurring during the early vegetative stage of a crop typically causes which physiological disruption?
(A) Destruction of the apical meristem leading to severe developmental stunting
(B) Premature senescence of cotyledons limiting early seedling establishment
(C) Immediate induction of floral transition bypassing the vegetative stage
(D) Excessive starch accumulation in leaves disrupting source-sink relationships

2003

117. Windbreaks and shelterbelts modify the microclimate of an agro-ecosystem primarily by altering which abiotic factor to reduce crop water stress?

(A) Solar radiation intensity by intercepting direct photosynthetically active radiation
(B) Soil texture class by altering bulk density and water-holding capacity of the field
(C) Wind velocity, thereby reducing boundary layer conductance and crop transpiration
(D) Ambient carbon dioxide concentration by generating localized atmospheric turbulence

2010
118. In terms of energy efficiency, why is the assimilation of nitrogen from nitrate (NO_{3-}) energetically more costly for a crop plant than assimilation from ammonium (NH_{4+})?
(A) Nitrate reduction to ammonium requires metabolic reducing power before amino acid synthesis
(B) Nitrate ions must be actively transported across vacuolar membranes consuming cytosolic ATP
(C) Nitrate accumulation directly inhibits enzymes of the Calvin-Benson cycle during fixation
(D) Ammonium uptake provides net high-energy phosphate bonds directly to the cellular pool

2016
119. A defining characteristic of shade-adapted leaves, distinguishing them from sun-adapted leaves, is:
(A) A higher light compensation point and a thicker palisade mesophyll layer
(B) Significantly elevated rates of dark respiration under low light regimes
(C) A complete absence of active stomata on the lower abaxial leaf epidermis
(D) A lower light compensation point and a higher specific leaf area metric

2024
120. Match the physiological parameter (List I) with its correct standard SI unit of measurement in crop science (List II):
List I: (Physiological Parameter)
P. Photosynthetically Active Radiation (PAR)
Q. Stomatal Conductance
R. Net Assimilation Rate (NAR)
S. Transpiration Rate
List II: (SI Unit)
1. mol m-2 s-1
2. μmol photons m-2 s-1
3. mmol H2O m-2 s-1
4. g m-2 day-1
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-3, R-4, S-1

2012
121. The Vapor Pressure Deficit (VPD) of the atmosphere is a critical driving force for which plant process?
(A) Photosynthetic electron transport within the thylakoid membrane
(B) Active phloem loading of sucrose from source leaves to sink organs
(C) Transpirational pull of water through the xylem vascular bundle
(D) Nodulation and nitrogen fixation by rhizobia in legume host roots

2004
122. At highly elevated VPD (very dry air), stomata in most crops will respond by:
(A) Opening wider to maximize transpirational cooling of the leaf
(B) Reversing water transport from the atmosphere back into the mesophyll
(C) Remaining completely insensitive and maintaining stable conductance
(D) Closing partially or fully to prevent catastrophic hydraulic failure

2001
123. The "Law of Diminishing Returns" in crop ecology, often formulated by Mitscherlich, relates crop yield mathematically to which independent variable?
(A) Increasing applications of a limiting growth factor (e.g., nitrogen fertilizer)
(B) Exponential growth of herbivorous insect pest populations in the crop canopy
(C) Systematic decreases in rhizosphere pH due to ammonium-based fertilization
(D) Linear increases in competing weed biomass during critical weed-free periods

2010
124. Which physiological variable is most heavily reliant on the maintenance of positive cell turgor pressure?
(A) Mitochondrial dark respiration rate
(B) Cell expansion and leaf elongation
(C) Photosynthetic photolysis of water
(D) Secondary cell wall lignin biosynthesis

2014
125. Identify the INCORRECT statement regarding the comparison between autecology and synecology.
(A) Autecology focuses on individual species life histories.

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(B) Autecology relies exclusively on global climate models.
(C) Synecology studies community dynamics and species interactions.
(D) Synecology involves understanding food webs and successional stages.

2012

126. A crop ecosystem differs from a natural ecosystem primarily due to:
(A) High subsidies of auxiliary energy, nutrients, and intensive human regulation
(B) Complete absence of primary and secondary consumers within the trophic web
(C) Significantly higher genetic and taxonomic diversity of primary producers
(D) Perfect closure of biogeochemical nutrient cycles without output losses

2025

127. The ratio of dry matter produced to the cumulative intercepted photosynthetically active radiation (PAR) over the growing season defines:
(A) Ecological transfer efficiency
(B) Agronomic harvest index
(C) Radiation use efficiency
(D) Crop transpiration ratio

2002

128. Arrange the biochemical events of the C_4 photosynthetic pathway in the correct chronological order.
1. Decarboxylation of malate in the bundle sheath
2. Fixation of CO_2 by PEP carboxylase in the mesophyll
3. Refixation of CO_2 by RuBisCO
4. Transport of malate to the bundle sheath

(A) 2, 4, 1, 3
(B) 1, 2, 3, 4
(C) 2, 1, 4, 3
(D) 4, 2, 1, 3

2016

129. The enzyme Superoxide Dismutase (SOD) acts in the cellular defense against ROS by catalyzing the conversion of the superoxide radical into which molecules?
(A) Water and gaseous carbon dioxide
(B) Adenosine triphosphate and reduced NADPH
(C) Hydrogen peroxide and molecular oxygen
(D) Proline osmoprotectant and glycine betaine

NODIA

2006

130. High night temperatures reduce final crop yield primarily by amplifying the rate of which physiological process?
(A) Photorespiratory carbon oxidation in the chloroplast
(B) Maintenance respiration, depleting valuable carbon reserves
(C) Root exudation of organic acids into the rhizosphere
(D) Stomatal conductance and opening dynamics in C_3 plants

2004

131. In agrometeorology, the term "Albedo" strictly refers to:
(A) The fractional absorption of longwave thermal infrared radiation by the soil surface
(B) The volumetric heat capacity of the canopy air space under turbulent wind conditions
(C) The fractional transmission of active photosynthetic radiation through leaves to soil
(D) The ratio of reflected shortwave radiation to incoming shortwave solar radiation

2025

132. Soils with high organic matter generally exhibit which physical response to incoming solar radiation compared to light-colored sandy soils?
(A) Lower albedo and faster warming
(B) Higher albedo and slower warming
(C) Perfect reflection of all thermal energy
(D) No difference in thermal dynamics

2024

133. The adaptation of deep and extensive root systems is most characteristic of crops originating in which Agro-ecological zone?
(A) Humid coastal plains
(B) Alpine temperate zones
(C) Arid and semi-arid tropics
(D) High rainfall deltaic regions

2016

134. Which biochemical pathway is considered the most water-efficient method of carbon fixation?
(A) CAM pathway
(B) C_3 pathway
(C) C_4 pathway
(D) Photorespiration

2002

135. Under typical field conditions, a C_3 crop transpiring 500 grams of water to produce 1 gram of dry matter has a Transpiration Ratio of:

(A) 0.002
(B) 50
(C) 500
(D) 5000

2004

136. Arrange the cellular organelles in the correct sequential order as they participate in the photorespiratory carbon oxidation cycle.
1. Peroxisome
2. Chloroplast
3. Mitochondrion

(A) 2, 1, 3
(B) 1, 2, 3
(C) 2, 3, 1
(D) 3, 1, 2

2011

137. Which phytohormone is primarily responsible for maintaining seed dormancy and is rapidly degraded upon exposure to specific environmental cues like chilling (stratification)?
(A) Gibberellic Acid (GA)
(B) Ethylene
(C) Abscisic Acid (ABA)
(D) Auxin (IAA)

2013

138. The physiological parameter T_{max} in heat stress biology designates the temperature at which:
(A) The crop canopy achieves its maximum physiological vegetative growth rate
(B) Stomatal apertures are open to their absolute maximum physical limit
(C) Vernalization and floral transition processes are successfully completed
(D) Net photosynthesis is halted due to enzyme denaturation and membrane failure

2018

139. Which optical platform is considered an "Active" remote sensor?
(A) Synthetic Aperture Radar (SAR)
(B) Landsat Operational Land Imager
(C) MODIS sensor on Terra satellite
(D) Handheld infrared thermometer

2015

140. Microwave remote sensing holds a distinct advantage for agricultural soil moisture estimation because:
(A) Microwaves strictly measure chlorophyll fluorescence
(B) Microwaves are highly sensitive to the dielectric constant of water
(C) Microwaves are blocked by cloud cover, providing pure atmospheric data
(D) Microwaves can only operate during peak daylight

2019

141. The specific wavelength boundary that defines the transition from Visible Red light to Near-Infrared (NIR) light is approximately:
(A) 400 nm
(B) 550 nm
(C) 700 nm
(D) 1000 nm

2014

142. The process of crop acclimation to progressive, slowly developing drought stress involves which physiological change?
(A) Osmotic adjustment and increased root-to-shoot allocation ratio
(B) Immediate shedding of all leaves
(C) Conversion from autotrophy to heterotrophy
(D) Complete irreversible destruction of the photosynthetic apparatus

2016

143. Which environmental parameter most directly dictates the potential rate of transpiration from a fully wetted crop canopy?
(A) Soil macronutrient concentration
(B) Atmospheric CO_2 concentration
(C) Net incident solar radiation
(D) Subsoil physical bulk density

2021

144. Given below are three statements concerning Net Assimilation Rate (NAR):
I. NAR is a measure of the net photosynthetic rate per unit leaf area.
II. NAR accounts for the carbon lost through plant respiration.
III. NAR remains perfectly constant throughout the entire life cycle of a crop.

Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2001

145. Why do C_4 crops generally exhibit a higher nitrogen use efficiency (NUE) than C_3 crops?
(A) C_4 crops substitute other structural proteins for nitrogen during amino acid synthesis
(B) C_4 crops form endosymbiotic associations with root nodules for atmospheric nitrogen fixation

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(C) C_4 crops require significantly less RuBisCO enzyme to achieve high photosynthetic rates
(D) C_4 crops bypass the Calvin-Benson cycle entirely to prevent carbon loss during assimilation

2003

146. Waterlogging causes a rapid drop in the redox potential of the soil, leading to the toxic accumulation of which reduced chemical species?
(A) Oxidized nitrate and sulfate ions
(B) Manganous (Mn2+) and ferrous (Fe2+) ions
(C) Dissolved oxygen and ozone molecules
(D) Exchangeable calcium and magnesium ions

2016

147. A limitation of using uncalibrated infrared thermometry to measure absolute canopy temperature is the requirement to know the canopy's:
(A) Latent heat of vaporization
(B) Specific leaf weight
(C) Transpiration ratio
(D) Emissivity

2008

148. According to the Stefan-Boltzmann law, the total thermal energy emitted by a crop canopy is proportional to the:
(A) Fourth power of its absolute temperature
(B) Square of its absolute temperature
(C) Cube of its absolute temperature
(D) Square root of its absolute temperature

2006

149. High concentrations of ozone (O_3) in the lower troposphere cause agricultural yield losses primarily by:
(A) Promoting global cooling via increased stratospheric aerosol formation
(B) Directing and blocking incoming PAR before it reaches the crop canopy
(C) Entering stomata and generating severe oxidative stress in the mesophyll
(D) Inhibiting biological nitrogen fixation and nodulation in rhizosphere soils

2008

150. Which crop is most classically utilized as a model for understanding the physiological and morphological responses to extreme chilling (non-freezing) stress?
(A) Maize
(B) Wheat
(C) Barley
(D) Oats

NODIA

2024

151. Freezing injury in plant tissues is ultimately a form of severe cellular:
(A) Heat shock
(B) Nutrient toxicity
(C) Anaerobiosis
(D) Dehydration

2022

152. Given below are four statements regarding the calculation and utility of the Crop Water Stress Index (CWSI):
I. CWSI ranges empirically from 0 (no stress) to 1 (maximum stress).
II. CWSI requires knowledge of ambient air temperature and VPD.
III. CWSI is calculated independent of canopy temperature.
IV. The upper baseline of CWSI represents a fully transpiring canopy.
Which of the above statements are correct?
(A) I and II
(B) I, II and IV
(C) II, III and IV
(D) I, III and IV

2015

153. Stomatal conductance (g_s) is inversely proportional to which of the following parameters?
(A) Leaf internal CO_2 concentration
(B) Transpiration rate
(C) Stomatal resistance (r_s)
(D) Photosynthetic rate

2018

154. The theoretical ecological optimum for crop yield is rarely achieved in open field agriculture primarily because:
(A) Crop genetic potential is inherently limited by evolutionary metabolic constraints
(B) Incident solar radiation levels are too weak to saturate C_3 photosynthesis in fields
(C) Available soil organic matter completely degrades within a single crop growing season
(D) Multiple suboptimal biotic and abiotic factors interact dynamically throughout the season

2001

155. Which agricultural management practice most effectively alters the microclimatic Leaf Area Index (LAI) to optimize light interception early in the season?
(A) Adjusting crop plant density and row spacing
(B) Executing deep primary tillage during fallow

(C) Applying selective pre-emergent herbicides
(D) Shift-scheduling the targeted date of harvest

2009

156. In the context of global warming, a projected 2°C rise in mean seasonal temperature is most likely to have what effect on wheat production in the Indo-Gangetic plains?
(A) Massive yield increase due to CO_2 fertilization completely offsetting elevated heat
(B) Significant yield reduction due to accelerated phenology and terminal heat stress
(C) Minimal change in total grain yield, with only vegetative biomass being stimulated
(D) Extended vegetative periods leading to delayed physiological maturity and harvest

2016

157. Photoperiodism regulates flowering in "Short-Day" plants. These plants actually flower in response to:
(A) A critically short period of diurnal darkness
(B) An uninterrupted dark period exceeding a critical length
(C) A continuous, unshaded twenty-four-hour cycle of light
(D) Short, intense pulses of red light during the night

2014

158. Soybean is Node-neutral, but generally classified according to its photoperiodic requirement as a:
(A) Short-day plant
(B) Long-day plant
(C) Day-neutral plant
(D) Long-short day plant

2023

159. Heliotropism (solar tracking) in leaves of crops like soybean and cotton serves what primary ecological function during water stress?
(A) Maximizing light capture by orienting leaves perpendicular to the solar beam
(B) Generating high hydraulic pull to actively transport water from deep roots
(C) Minimizing heat load and photoinhibition by orienting parallel to solar rays
(D) Attracting insect pollinators by increasing canopy visibility from above

2006

160. Given below are five statements concerning the spatial distribution of Indian crops based on climate:
I. Saffron is restricted strictly to the temperate climate of Kashmir.
II. Coconut requires a hot, humid coastal climate without frost.
III. Tea demands high rainfall with excellent soil drainage.
IV. Pearl millet is widely grown in the humid eastern coastal plains.
V. Cardamom thrives in the cool, shaded understory of the Western Ghats.
Which of the above statements are correct?
(A) I, II, III and V
(B) I, II, IV and V
(C) II, III, IV and V
(D) I, III, IV and V

2021

161. The geographical limit of commercial rubber tree (Hevea brasiliensis) cultivation is strictly confined by its intolerance to:
(A) Elevated atmospheric humidity
(B) Strongly acidic soil conditions
(C) Frost and prolonged dry seasons
(D) Intense, heavy monsoon rainfall

2004

162. The agro-climatic zoning of India characterizes Zone VII (Eastern Plateau and Hills Region) by which dominant crop cultivation?
(A) Wheat and mustard
(B) Rainfed rice
(C) Apples and walnuts
(D) Pearl millet and cluster bean

2021

163. The physiological parameter "Intrinsic Water Use Efficiency" (WUE_i) is mathematically defined at the leaf level as the ratio of:
(A) Total transpirational water loss to net carbon assimilation rate
(B) Total active leaf area to dry structural weight of leaf tissues
(C) Available volumetric soil water to total belowground root biomass
(D) Net carbon assimilation rate to stomatal conductance ($\frac{A}{g_s}$)

2006

164. What is the effect of severe nitrogen deficiency on crop canopy spectral reflectance?
(A) Increased reflectance in the visible green and red bands due to reduced chlorophyll absorption
(B) Significant increase in reflectance across the near-infrared region due to cellular changes
(C) Total and complete absorption of all incident visible light wavelengths by the canopy

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(D) Decreased reflectance within the shortwave infrared bands due to canopy water content shifts

2017

165. A sudden drop in the NDVI value of a previously healthy crop field in mid-season is most likely an indicator of:
(A) A dramatic sudden surge in photosynthetic light-use efficiency
(B) The crop plants actively shifting from C_3 to CAM carbon pathways
(C) Rapid onset of biotic or abiotic stress causing canopy degradation
(D) Systematic increases in overall soil organic carbon concentrations

2022

166. A "Sun-synchronous" satellite orbit is particularly valuable for agricultural remote sensing because it ensures:
(A) Images are captured at exactly the same local solar time, minimizing shadow variations
(B) The satellite orbit is geostationary, remaining over the exact same field continuously
(C) The satellite physically adjusts its orbit closer to the sun during winter seasons
(D) The active radar sensors operate continuously without any reliance on solar radiation

2021

167. Spatial resolution in remote sensing refers specifically to:
(A) The total number of discrete electromagnetic bands the sensor is able to resolve
(B) The temporal frequency with which a satellite sensor revisits a specific location
(C) The absolute precision and accuracy of the radiometric sensor-calibration process
(D) The smallest detectable area on the ground represented by a single image pixel

2016

168. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Elevated atmospheric CO_2 generally increases the yield of C_3 crops more significantly than C_4 crops.
Reason (R): The photosynthetic enzyme RuBisCO in C_3 crops is not CO_2-saturated at current atmospheric levels, allowing for increased carbon assimilation under elevated CO_2.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

169. What is the fundamental mechanism by which a cyclone induces secondary soil salinity in coastal agricultural lands?
(A) Strong winds increase the transpiration of fresh water out of the soil
(B) Cyclones trigger the upward capillary movement of deep saline groundwater
(C) Storm surges inundate fields with highly saline ocean water
(D) Heavy rainfall dissolves existing salt crystals in the air

2018

170. Which of the following defines the "Light Saturation Point" in crop physiology?
(A) The threshold irradiance level below which cellular respiratory losses exceed photosynthetic gains
(B) The specific irradiance level at which the net photosynthetic rate exactly equals dark respiration
(C) The physical point at which the leaf cuticle reflects or absorbs one hundred percent of incident light
(D) The irradiance level beyond which further increases in light do not increase net photosynthetic rates

2011

171. The phenomenon of "Photoinhibition" occurs when a crop is exposed to:
(A) Light levels exceeding photosynthetic dissipation capacity, causing damage to Photosystem II
(B) Persistent light levels remaining below the vegetative compensation point during early growth
(C) Systematic exposure of long-day crops to short photoperiods during the active vegetative stage
(D) Continuous vegetative darkness for extended periods leading to complete etiolation of leaves

2005

172. Which agricultural zone is recognized as a Vavilovian mega-diversity center, particularly rich in wild relatives of crops like eggplant, pigeonpea, and black gram?

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(A) Mediterranean center
(B) Indian (Hindustan) center
(C) Abyssinian center
(D) Central Asiatic center

2006
173. The reduction of GPP to NPP is mathematically accounted for by autotrophic respiration, which is functionally divided into which two components?
(A) Photorespiration and mitochondrial dark respiration
(B) Growth respiration and cellular maintenance respiration
(C) Active aerobic respiration and anaerobic fermentation
(D) Direct root respiration and vegetative stem respiration

2024
174. A high "Harvest Index" is the hallmark of modern high-yielding varieties (e.g., Green Revolution semi-dwarf wheat), achieved primarily by altering the partitioning of NPP away from which organ?
(A) Structural stem tissues (straw)
(B) Developing reproductive grain
(C) Belowground root structures
(D) Active photosynthetic leaves

2001
175. Which parameter is critical for calculating the Heat Unit Efficiency (HUE) of a crop?
(A) Total economic grain yield divided by cumulative seasonal rainfall
(B) Peak green leaf area index multiplied by incident active radiation
(C) Total dry biomass divided by accumulated Growing Degree Days (GDD)
(D) Leaf-level photosynthetic rate divided by instantaneous transpiration

2018
176. Match the spectral index (List I) with its primary application in agricultural remote sensing (List II):
List I: (Spectral Index)
P. NDVI
Q. NDWI
R. CWSI
S. EVI
List II: (Application)
1. Canopy water stress and temperature mapping
2. High-biomass canopy monitoring without saturation
3. General vegetation vigor and biomass tracking
4. Leaf and canopy liquid water content
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-1, R-4, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-4, R-1, S-2

2019
177. The term "Phyllotaxy" is relevant to canopy light interception because it describes the:
(A) Chemical composition of the cuticle
(B) Internal structure of the chloroplast
(C) Arrangement and geometry of leaves on the stem
(D) Stomatal distribution on the leaf surface

2019
178. Vertical leaf orientation (e.g., erectophile canopies) is advantageous in high-density crop stands because it allows for:
(A) Confining major light interception strictly to the uppermost horizontal leaves
(B) Facilitating deeper solar radiation penetration to illuminate lower canopy leaves
(C) Promoting complete shading of the soil surface immediately following crop emergence
(D) Preventing all transpirational water loss by minimizing leaf boundary layers

2003
179. The interaction of Liebig's Law of the Minimum and multiple resources suggests that supplying the single most limiting nutrient will:
(A) Stimulate a continuous, infinite increase in overall biomass and grain yield
(B) Suppress the physiological ability of the root system to absorb other ions
(C) Have no measurable agronomic or physiological effect on final crop harvest
(D) Promote yield increases until a different factor becomes the new limiting resource

NODIA

2014
180. A plant classified as an "Obligate Halophyte" differs from a "Facultative Halophyte" in that it:
(A) Requires an elevated saline environment to optimize growth and complete its life cycle
(B) Tolerates moderate salt concentrations but achieves its highest biomass in fresh water
(C) Excludes toxic sodium and chloride ions strictly at the root-endodermis barrier
(D) Undergoes rapid, irreversible cellular necrosis immediately upon contact with sodium

2021

181. Why is the 10 percent ecological law an oversimplification when applied directly to complex modern agricultural systems?
(A) It presumes that primary photosynthesizing producers operate at maximum theoretical efficiency
(B) It asserts that thermodynamic energy systematically increases with higher trophic levels
(C) It overlooks the substantial artificial energy subsidies (fertilizer, fuel) inputted by humans
(D) It was mathematically derived for and applies exclusively to pelagic marine aquatic webs

2004

182. A crop species exhibiting C_3 photosynthesis will typically show which gas exchange characteristic compared to a C_4 crop?
(A) Higher photorespiration rate
(B) Lower transpiration rate
(C) Lower CO_2 compensation point
(D) Higher optimal temperature for photosynthesis

2006

183. The biophysical process of transpirational cooling prevents heat-induced protein denaturation in crop leaves by utilizing the properties of water's:
(A) Low specific heat capacity
(B) High surface tension
(C) Capillary action
(D) High latent heat of vaporization

2019

184. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Methane emission is significantly higher in continuously flooded rice fields compared to fields under alternate wetting and drying (AWD) management.
Reason (R): Alternate wetting and drying introduces oxygen into the soil profile, inhibiting the activity of strictly anaerobic methanogens.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2003

185. In the context of abiotic stress, "Osmotic Adjustment" fundamentally lowers the osmotic potential (Ψ_π) of the cell without decreasing cell volume. This mechanism allows the plant to maintain:
(A) Significantly elevated rates of photorespiratory carbon oxidation in light
(B) A perfectly constant leaf temperature independent of ambient heat loads
(C) Positive cell turgor pressure at substantially lower tissue water potentials
(D) Complete stomatal opening and high conductance during severe soil drought

2002

186. Which structural polymer increases significantly in cell walls under drought stress, increasing tissue rigidity and reducing digestibility in forage crops?
(A) Starch
(B) Pectin
(C) Inulin
(D) Lignin

2001

187. The geographical spread of cultivated sunflower (Helianthus annuus) is favored by its robust physiological ability to:
(A) Extract water from deep soil profiles via a vigorous taproot system
(B) Tolerate prolonged soil waterlogging and hypoxic root zone conditions
(C) Survive extended sub-zero winters during active reproductive stages
(D) Fix atmospheric nitrogen symbiotically through rhizobial association

2011

188. Which climatic variable dictates the northernmost geographical limit of winter wheat cultivation globally?
(A) Extreme summer heat waves that inhibit pollination
(B) Minimum winter survival temperatures (winterkill)
(C) Excessive cumulative rainfall exceeding 2000 mm
(D) Absolute concentration of tropospheric carbon dioxide

2018

189. In agro-ecological zoning, the "Bioclimate" classification heavily weights which specific metric to determine moisture availability for crops?
(A) Cumulative simple total annual rainfall of the region

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(B) The ratio of precipitation to potential evapotranspiration
(C) Mean annual absolute atmospheric humidity near the surface
(D) Extreme maximum recorded wind speed during crop growth

2005
190. What is the fundamental agricultural implication of Shelford's Law of Tolerance regarding micronutrient application?
(A) Both deficiency and severe excess (toxicity) of a nutrient will limit crop yield
(B) Micronutrient fertilizers should be applied in unlimited quantities to fields
(C) Micronutrient supply exclusively impacts minimum potential crop yield metrics
(D) Essential micronutrients can metabolically substitute for primary macronutrients

2007
191. Poor drainage in soils leads to a rapid depletion of oxygen in the root zone, directly causing:
(A) Enhanced root elongation into deep profiles
(B) Increased nodulation rates in legume crops
(C) Hypoxia and suppression of aerobic root respiration
(D) Rapidly accelerated rates of mineral uptake

2005
192. Match the specific stress response molecule (List I) with its functional role in crop abiotic stress tolerance (List II):
List I: (Stress Response Molecule)
P. Proline
Q. Late Embryogenesis Abundant (LEA) proteins
R. Superoxide Dismutase (SOD)
S. Abscisic Acid (ABA)
List II: (Functional Role)
1. ROS scavenging enzyme
2. Osmoprotectant and cellular stabilizer
3. Stomatal closure signaling hormone
4. Desiccation protection chaperone protein
(A) P-1, Q-4, R-2, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-2, Q-1, R-4, S-3
(D) P-2, Q-4, R-1, S-3

2011
193. The specific biological function of Kranz anatomy in C_4 plants is essentially a form of:
(A) Thermal insulation of internal mesophyll tissue layers
(B) Mechanical defense against chewing herbivorous insects
(C) Spatial compartmentalization of photosynthetic enzymes
(D) Water storage and hydraulic buffering in succulent cells

NODIA

2021
194. The measurement of specific leaf area (SLA), an important parameter in crop growth analysis, is calculated as the ratio of:
(A) Leaf mass to leaf volume
(B) Leaf area to leaf dry mass
(C) Leaf area to total plant mass
(D) Leaf length to main stem length

2003
195. Which of the following is considered an "Extensive" property of an agro-ecosystem rather than an intensive property?
(A) Canopy temperature
(B) Leaf nitrogen concentration percentage
(C) Stomatal conductance per unit leaf area
(D) Total canopy dry biomass of an entire field

2018
196. The "Ozone Hole" in the stratosphere, while distinct from global warming, impacts agricultural ecosystems by increasing the surface penetration of which damaging radiation?
(A) Ultraviolet-B (UV-B)
(B) Near-Infrared (NIR)
(C) Shortwave Microwave
(D) High-energy Gamma rays

2002
197. UV-B radiation damages crop plants fundamentally by causing what molecular disruption?
(A) Direct formation of lethal ice crystals in the cell vacuole
(B) Systematic destruction of the Kranz anatomy bundle sheath cells
(C) Induction of pyrimidine dimers, resulting in severe DNA damage
(D) Chemical polymerization of leaf cuticular wax barrier layers

2002
198. The primary evolutionary advantage of the CAM photosynthetic pathway is to maximize survival under which specific environmental regime?
(A) Extremely arid conditions with high daytime temperatures and low water availability
(B) Waterlogged and hypoxic soils with high levels of organic matter decay in the basin
(C) Highly shaded conditions beneath dense

forest understories with low incident radiation
(D) Cold high-altitude alpine zones with low atmospheric pressure and continuous frost

2013
199. What distinguishes "Dark Respiration" from "Photorespiration" in a biochemical context?
(A) Dark respiration is light-dependent, whereas photorespiration occurs strictly in the dark
(B) Dark respiration utilizes RuBisCO, whereas photorespiration utilizes mitochondrial enzymes
(C) Dark respiration is restricted to roots, whereas photorespiration occurs only in stems
(D) Dark respiration generates useful ATP, whereas photorespiration dissipates energy without ATP

2017
200. In thermal remote sensing for irrigation scheduling, a canopy that is significantly warmer than the ambient air temperature unequivocally indicates:
(A) The canopy is well-watered, keeping stomata open to maximize carbon uptake
(B) The canopy is experiencing severe water deficit, halting transpirational cooling
(C) The crop has reached physiological maturity and initiated chlorophyll breakdown
(D) A heavy infestation of vascular pathogens has blocked phloem nutrient transport

2004
201. Which metric relies on sequentially harvesting plant biomass at different time points to calculate the efficiency of dry matter production over time?
(A) Leaf Area Index (LAI)
(B) Transpiration Ratio (TR)
(C) Crop Growth Rate (CGR)
(D) Relative Water Content (RWC)

2014
202. The equation $CGR = NAR \times LAI$ mathematically demonstrates that absolute crop growth is a function of both:
(A) The maximum depth of active roots and overall stomatal conductance of leaves
(B) Soil water availability metrics and macronutrient uptake rates in the field
(C) Final vegetative plant height and structural main stem thickness properties
(D) The net photosynthetic rate of leaves and the total leaf area intercepting light

2017
203. Which minor greenhouse gas, often overlooked, is produced in significant quantities by the microbial processes of nitrification and denitrification in fertilized agricultural soils?
(A) Nitrous oxide (N_2O)
(B) Carbon monoxide (CO)
(C) Sulfur hexafluoride (SF_6)
(D) Hydrofluorocarbons (HFCs)

2024
204. Isabgol (Plantago ovata), a highly valued medicinal crop, is geographically restricted to the arid and semi-arid zones of Western India primarily because:
(A) It requires intense seasonal monsoon rain during the critical seed-setting phase
(B) High humidity and rainfall during maturity trigger shattering and reduce seed quality
(C) It relies on highly weathered, acidic lateritic soils to mobilize micronutrients
(D) It is an obligate halophyte requiring elevated soil electrical conductivity levels

2019
205. The primary consequence of global climate change on the geographic distribution of Indian agriculture is predicted to be:
(A) The absolute ecological extinction and complete eradication of tropical C_4 crop species
(B) A poleward and upward altitudinal shift in the optimal zones for cool-season crops
(C) A significant geographical expansion of temperate agro-climatic zones southward
(D) The total thermodynamic collapse and elimination of the summer monsoon wind systems

2004
206. In assessing the ecological footprint of agriculture, "Virtual Water" is a concept defined as:
(A) The total volume of freshwater used to produce a commodity from field to consumer
(B) The unmeasured capillary water retained in deep soil profiles beyond root access
(C) The metabolic water synthesized via cellular respiration during carbohydrate oxidation
(D) The total mass of precipitable water vapor residing in the local atmospheric column

2004
207. Which specific biochemical cycle uniquely characterizes the dark reactions (carbon fixation)

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in all autotrophic crop plants, regardless of whether they are C_3, C_4, or CAM?
(A) The Krebs cycle
(B) The Glyoxylate cycle
(C) The Calvin-Benson cycle
(D) The Cori cycle

2021

208. The concept of "Allelopathy" represents a specific type of biotic interaction in an agro-ecosystem where:
(A) Two crops mutually benefit through shared root mycorrhizal connections
(B) Herbivorous pests completely defoliate a monoculture crop population
(C) Insect pollinators selectively visit flowers of specific crop cultivars
(D) One plant suppresses another via releasing biochemical toxic inhibitors

2010

209. Secondary centers of origin (or diversity) defined by Vavilov differ from primary centers in that they:
(A) Do not contain any wild ancestral or closely related relatives of the domesticated crop
(B) Serve as the absolute geological starting point for the evolutionary origin of species
(C) Developed after domestication, yielding unique morphological variations in new climates
(D) Contain only sterile interspecific hybrid plants unable to undergo natural reproduction

2001

210. Which primary physical characteristic of electromagnetic radiation is manipulated in radar (microwave) remote sensing to determine the structural geometry of a crop canopy?
(A) The absolute thermal temperature of the terrestrial emission
(B) The phase and polarization of the backscattered microwave signal
(C) The ultraviolet absorption spectra of canopy epidermal cells
(D) The active chemical red fluorescence of structural chlorophyll

****

NODIA

ANSWERS

1. (B) The study of an individual crop species and its specific interaction with the environment
Autecology focuses on the ecological relationships of a single species throughout its life cycle in response to environmental factors. In agricultural contexts, this approach isolates a particular crop to evaluate how specific moisture, temperature, and nutrient conditions influence its physiological performance, development, and overall productivity, rather than studying complex multi-species community dynamics.

2. (D) The complex interactions among crop populations, weeds, and soil microbiota
Synecology involves the study of groups of organisms or ecological communities associated together as a unit. In agricultural systems, this branch of ecology examines how cultivated crops, competing weed species, beneficial or pathogenic soil microorganisms, and insect populations interact collectively with each other and their shared physical environment to shape the entire agro-ecosystem function.

3. (A) Photosynthetically active radiation
Abiotic components represent the non-living physical and chemical elements in an ecosystem. Photosynthetically active radiation is a primary physical factor, delivering the light energy required to drive carbon fixation in plants. Other options, such as fungi, organic carbon pools, and bacteria, represent biotic elements, biological products, or living organisms that interact with these primary physical inputs.

4. (C) Biotic components modify the microclimate, altering localized abiotic conditions
Biological organisms interact dynamically with their physical environment by modifying localized conditions. In crop fields, the developing canopy shades the soil surface, which lowers soil temperature, increases relative humidity, and reduces wind speed. This physical modification of the microclimate demonstrates how living components actively alter abiotic variables to create a distinct micro-environment within the agricultural canopy.

5. (A) Photoautotrophs
The primary trophic level in any energy flow model contains the primary producers. Photoautotrophs, such as green crops and plants, use solar energy to synthesize organic molecules from inorganic carbon dioxide and water through photosynthesis. They capture radiant energy and convert it into chemical energy, forming the essential energetic foundation for all subsequent consumer levels.

6. (B) 1,000 kilocalories
The ten percent law of ecological transfer dictates that approximately ten percent of the energy stored as organic matter at one trophic level is transferred to the next level. When a crop canopy assimilates ten thousand kilocalories of energy, only ten percent of this energy is successfully incorporated and made available to primary herbivores.

7. (B) Cellular respiration
Energy transfer between successive trophic levels is inefficient due to thermodynamics. A large portion of the assimilated energy is consumed by the organisms themselves to support maintenance, growth, and cellular respiration, dissipating as metabolic heat. Consequently, only a small fraction of energy remains stored as biomass to be passed on to consumer organisms.

8. (B) II and III
Energy flow in agricultural ecosystems operates unidirectionally, moving from the sun to producers and then through consumers, rather than bidirectionally. This thermodynamic process conforms to physical laws where energy is converted from one form to another, with a significant portion inevitably dissipating as metabolic heat at each successive trophic stage of the food web.

9. (D) Energy transfer efficiency
Lindeman's trophic-dynamic concept models ecosystems based on energy flow and the efficiency of energy transfer across trophic levels. This quantitative framework describes how energy is captured by autotrophs and subsequently transferred to herbivores and

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carnivores, emphasizing the progressive loss of usable energy and metabolic dissipation that limits the length of food chains.

10. (A) It includes a feedback loop for recycled energy
Odum's universal energy flow model illustrates the unidirectional path of energy through an ecosystem, showing that energy decreases with each transfer and cannot be recycled. While nutrients cycle continuously through biogeochemical loops, energy is dissipated as heat and must be constantly replenished by solar radiation, meaning no feedback loop exists for recycled energy.

11. (B) Total organic matter synthesized by producers
Gross Primary Productivity represents the total rate at which photosynthetic producers capture solar energy and convert it into chemical energy in the form of organic matter over a specific period. This metric accounts for the entire quantity of carbon fixed by the plant canopy before subtracting any energy expended during autotrophic respiration.

12. (B) $NPP = GPP - R$
Net Primary Productivity represents the actual accumulation of organic matter that remains after accounting for metabolic demands. Mathematically, it is calculated by subtracting autotrophic respiration, which is the carbon lost through cellular respiration for maintenance and growth, from the gross primary productivity, reflecting the net biomass available to consumers and decomposers.

13. (A) Eddy covariance technique
The eddy covariance technique is a high-precision micrometeorological method used to continuously measure the exchange of carbon dioxide, water vapor, and energy between the crop canopy and the atmosphere. By monitoring vertical wind speed and gas concentrations simultaneously, this non-invasive approach provides real-time estimates of net ecosystem exchange over vast agricultural areas.

14. (C) Photorespiration and dark respiratory losses
The divergence between Gross Primary Productivity and Net Primary Productivity is caused by respiratory carbon losses. Crops must consume a portion of their synthesized carbohydrates to generate metabolic energy through dark respiration, while C_3 plants lose additional carbon through photorespiration. These joint processes reduce the amount of fixed carbon preserved as net plant biomass.

15. (D) The ratio of economic yield to biological yield
The harvest index represents the efficiency of an agricultural crop in allocating its accumulated biomass into harvested products. It is calculated by dividing the dry mass of the economically valuable organ by the total biological yield, which constitutes the entire aboveground net primary productivity generated by the plant during the growing season.

16. (A) I, II and III
Liebig's Law of the Minimum focuses on resources in the scarcest supply, not abundant ones. Shelford's Law of Tolerance dictates that both minimum and maximum limits of environmental factors determine organism success. Ecological optima represent conditions where crop growth is maximized, not minimized. Consequently, these three statements are scientifically incorrect regarding basic ecological principles.

17. (B) Scarcest supply relative to plant needs
Liebig's Law of the Minimum states that crop growth and yield are controlled not by the total resources available, but by the essential nutrient or environmental factor that is most deficient relative to the plant's physiological requirements. Increasing the supply of other abundant resources will not improve growth until this limiting factor is addressed.

NODIA

18. (D) Organisms possess specific minimum, optimum, and maximum tolerances
Shelford's Law of Tolerance states that the environmental factors governing an organism's survival and distribution operate within specific bounds. An organism exhibits a range of tolerance bounded by physiological minimum and maximum limits, with an optimum range in between. Survival and productivity decline when environmental conditions fall outside these specialized limits.

19. (A) Euryecious
Organisms that can tolerate a wide range of variation in environmental conditions are referred to as euryecious. A crop cultivar that

thrives across diverse soil pH levels demonstrates this wide adaptability, whereas stenocious plants are highly sensitive and restricted to narrow environmental ranges, such as specific salinity, temperature, or moisture limits.

20. (A) 2, 1, 4, 3
The trophic model of agricultural ecosystems begins with solar radiation, which provides the primary energy input. This energy is intercepted by primary producers to synthesize biomass. Herbivores, acting as primary consumers, feed directly on these producers. Finally, predators or parasites, functioning as secondary consumers, feed on the primary consumers to complete the sequence.

21. (A) Dense leaf pubescence
Dense leaf pubescence consists of fine epidermal hairs that create a boundary layer of still air over the leaf surface, reducing the water vapor gradient. These structures also increase leaf albedo, reflecting excess solar radiation and lowering leaf temperature, which collectively minimizes transpirational water loss in plants adapted to arid environments.

22. (D) Soil waterlogging and hypoxia
Aerenchyma tissue is characterized by interconnected gas-filled spaces that develop within plant roots and stems. This anatomical adaptation facilitates the internal transport of oxygen from the atmospheric shoots down to the roots during soil waterlogging and hypoxia, ensuring cellular respiration continues even when soils are completely saturated with water.

23. (B) Acting as an osmoprotectant to maintain turgor
Proline acts as a compatible organic solute that accumulates rapidly in leaf cells during water deficit. By increasing intracellular solute concentration, proline lowers cellular osmotic potential, facilitating water uptake and helping to maintain cell turgor and membrane integrity. This biochemical response prevents metabolic damage and supports physiological function under drought stress.

24. (C) I, III and IV
Carbon dioxide serves as the baseline reference with a global warming potential of one, whereas methane possesses a significantly higher potential than carbon dioxide. Nitrous oxide emissions arise predominantly from agricultural soils treated with synthetic nitrogen fertilizers, and livestock enteric fermentation is a major source of atmospheric methane, confirming the validity of these statements.

25. (D) Applying synthetic nitrogen-based fertilizers
The application of synthetic nitrogen fertilizers adds reactive nitrogen to agricultural soils. This excess nitrogen fuels microbial nitrification and denitrification pathways, leading to the production and release of nitrous oxide into the atmosphere. This specific practice represents the largest anthropogenic source of this potent greenhouse gas within global agricultural operations.

26. (A) Its high infrared absorption and long atmospheric lifetime
The elevated global warming potential of nitrous oxide is driven by its molecular properties. Nitrous oxide molecules absorb thermal infrared radiation much more efficiently than carbon dioxide. Additionally, its high chemical stability allows it to persist in the atmosphere for over a century, magnifying its cumulative warming impact over its lifetime.

27. (B) Earlier anthesis and a shorter grain-filling period
Elevated temperatures associated with climate shifts accelerate the accumulation of thermal time or growing degree days in crops. This accelerated development causes plants to reach anthesis earlier in the season. Consequently, the duration of the grain-filling phase is truncated, often reducing final kernel size, weight, and overall agricultural yields.

28. (B) $GDD = \frac{(T_{\max} + T_{\min})}{2} - T_{base}$
Growing Degree Days quantify daily thermal energy accumulation relative to crop development. The calculation averages the daily maximum and minimum temperatures to estimate the mean temperature, and then subtracts the base temperature, which represents the physiological threshold below which crop growth ceases, providing a standardized measure of developmental progress.

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29. (B) Toward higher latitudes and higher altitudes
Global warming increases average temperatures across traditional farming areas, making current low-latitude and low-altitude zones too warm

for cool-season crops. To find the cooler thermal conditions required for proper growth and development, the optimal geographic range for these crops shifts toward higher latitudes and higher elevations.

30. (B) 15
The Planning Commission of India divided the nation into fifteen distinct agro-climatic zones during the formulation of the Seventh Five-Year Plan. This classification was based on regional characteristics including climate, soil profile, water availability, and cropping systems, aiming to develop targeted agricultural planning strategies suited to local conditions.

31. (D) Agro-bioclimate, length of growing period, and soilscape
The National Bureau of Soil Survey and Land Use Planning established twenty agro-ecological zones by integrating physiological, climatic, and soil datasets. The classification relies on agro-bioclimate, length of growing period, and soilscape characteristics, ensuring that each zone reflects a homogeneous ecological unit for sustainable agricultural management.

32. (C) A is true but R is false.
The Trans-Gangetic Plain is characterized by high productivity and intensive, tube-well-driven irrigation systems. However, this zone receives relatively low to moderate natural annual rainfall, which makes it highly dependent on extensive groundwater extraction and canal systems. This high demand for water has led to the overexploitation of regional aquifers.

33. (B) Nikolai Vavilov
Nikolai Vavilov formulated the theory of centers of origin of cultivated plants based on extensive global germplasm collections. He postulated that geographic regions displaying the greatest genetic diversity of a particular crop and its wild relatives indicate where the species was originally domesticated, establishing a vital framework for crop breeding.

34. (D) Mesoamerica
According to Vavilovian geographic classifications, Mesoamerica is recognized as the primary center of origin for maize. Domesticated thousands of years ago from its wild ancestor, teosinte, in southern Mexico, this region preserves the highest genetic diversity and the closest wild relatives of modern cultivated maize varieties.

35. (A) Temperature regimes and precipitation patterns
The global distribution of agricultural crops is shaped by macroclimatic conditions. Temperature regimes dictate growing season duration and frost risk, while precipitation patterns govern soil moisture availability. These two interacting physical forces establish the primary environmental boundaries that determine whether a specific crop can be successfully cultivated in a region.

36. (C) Oryza sativa
Oryza sativa is uniquely adapted to grow in completely flooded soils. The plant forms specialized cortical aerenchyma tissues that allow oxygen to diffuse from the atmosphere down into the roots. This internal gas transport system prevents root hypoxia, enabling successful growth and grain production in saturated soils where other cereals would suffocate.

37. (A) Drought and high ambient temperatures
Pearl millet is highly concentrated in northwestern India due to its tolerance to dry and hot environments. The crop possesses morphological and physiological traits, such as a deep root system and rapid development, allowing it to yield reliably under low, erratic rainfall and high temperatures that restrict other major cereals.

38. (D) Cool, dry winters followed by a warm ripening period
Chickpea is a cool-season grain legume adapted to post-monsoon winter conditions in India. It requires low night temperatures during early vegetative growth to establish its canopy, followed by dry weather and warmer temperatures during flowering, pod development, and seed ripening. Wet, humid conditions promote disease and hinder proper pod development.

39. (B) Saffron (Crocus sativus)
Saffron is a high-value medicinal and spice plant adapted to high-altitude temperate climates. It requires cool temperatures, low relative humidity, and well-drained soils, which are found in temperate Himalayan valleys. Other crops like ashwagandha or senna are adapted to warm tropical or semi-arid plains of India.

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40. (A) P-3, Q-2, R-1, S-4
Black pepper requires hot, humid tropical climates with high rainfall. Mustard is a cool-season winter crop susceptible to late frost. Groundnut is adapted to warm, semi-arid regions with well-drained sandy loam soils. Sorghum exhibits exceptional drought tolerance and thrives in hot, semi-arid conditions, aligning each crop with its specific climatic requirements.

41. (D) Intracellular ice crystal formation
Frost damage occurs when sub-zero temperatures induce the freezing of water within plant tissues. The formation of sharp ice crystals inside the cell cytoplasm mechanically punctures and destroys organelle and plasma membranes. Upon thawing, the compromised cells lose structural integrity, leading to rapid cellular collapse and tissue death.

42. (A) Pollen sterility and reduced grain setting
High temperature stress during wheat anthesis damages reproductive organs. Heat impairs tapetal function and pollen development, leading to high pollen sterility and failure of fertilization. This disruption significantly reduces grain set and spikelet fertility, leading to lower grain numbers per spike and reducing overall grain yield.

43. (B) Mechanical lodging and grain shattering
Cyclonic storms impact mature standing crops through physical force. High-velocity winds and heavy rainfall cause crop lodging, bending or breaking the stems. Additionally, this mechanical force causes grain shattering in mature panicles and spikes, detaching the grain and dropping it onto the soil, which leads to harvest losses.

44. (B) 400 to 700 nm
Photosynthetically Active Radiation represents the spectral range of solar radiation that photosynthetic pigments, primarily chlorophylls, can absorb and use to drive carbon fixation. This range corresponds to wavelengths between four hundred and seven hundred nanometers, matching the visible light spectrum that drives chemical reactions in agricultural plants.

45. (A) Total leaf area to ground surface area
The Leaf Area Index is a dimensionless value that quantifies the canopy density of a crop. It is defined as the total one-sided green leaf area per unit of ground surface area below it. This index is a critical driver of solar radiation interception, transpiration rates, and overall canopy photosynthesis.

46. (C) The Beer-Lambert Law
The attenuation of solar radiation as it passes downward through a crop canopy is described by the Beer-Lambert Law. This physical principle states that light intensity decreases exponentially with increasing cumulative leaf area, governed by an extinction coefficient that depends on canopy traits, such as leaf angle and spatial distribution.

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47. (D) Highly horizontal leaves intercepting top canopy light
An extinction coefficient value close to one indicates that the crop canopy has horizontal leaf angles. Horizontal leaves intercept light efficiently in the upper layers, preventing light from penetrating into the lower canopy. In contrast, vertical leaves have a lower extinction coefficient, allowing solar radiation to reach deeper leaves.

48. (A) Carbon dioxide < Methane < Nitrous oxide
The global warming potential compares the heat-trapping ability of greenhouse gases over a hundred-year period relative to carbon dioxide, which is assigned a value of one. Methane is roughly twenty-eight times more potent than carbon dioxide, while nitrous oxide is nearly two hundred and sixty-five times more potent, establishing this increasing sequence.

49. (B) Cellular respiration
The light compensation point is the specific level of light intensity where the rate of photosynthetic carbon dioxide fixation matches the rate of respiratory carbon dioxide release. At this precise point, the net exchange of carbon dioxide between the crop leaf and the surrounding atmosphere is zero, resulting in no net biomass gain.

50. (D) C_4 crops like maize
C_4 crops like maize possess high light saturation points due to their specialized carbon-concentrating mechanisms. Unlike C_3 crops, which saturate at low to moderate light levels, C_4 plants increase their photosynthetic rate with rising solar radiation. This adaptation allows them to use intense sunlight efficiently without suffering from photorespiration.

51. (A) PEP carboxylase
The carbon dioxide compensation point is lower in C_4 plants because of PEP carboxylase. This enzyme has a high affinity for inorganic carbon, allowing it to fix carbon dioxide even at low cellular concentrations. It concentrates carbon around RuBisCO in the bundle sheath cells, reducing photorespiratory losses in these plants.

52. (C) Kranz anatomy
The C_4 photosynthetic pathway requires Kranz anatomy, characterized by ring-like arrangements of mesophyll cells surrounding bundle sheath cells. This structure allows spatial separation of carbon fixation. PEP carboxylase fixes carbon dioxide in the mesophyll, and the resulting four-carbon acids are transported to the bundle sheath to deliver carbon directly to RuBisCO.

53. (A) Temporal separation between day and night
Crassulacean Acid Metabolism plants are distinguished by a temporal separation of carbon fixation. To conserve water in arid zones, CAM plants open their stomata at night to fix carbon dioxide into malate. During the day, stomata remain closed to prevent transpiration, and stored malate is decarboxylated to release carbon dioxide for the Calvin cycle.

54. (D) RuBisCO acts as an oxygenase, releasing fixed CO_2
Under hot and dry conditions, stomatal closure reduces internal carbon dioxide levels relative to oxygen. Under these conditions, the dual-function enzyme RuBisCO acts as an oxygenase rather than a carboxylase, initiating photorespiration. This process consumes oxygen and releases previously fixed carbon dioxide, reducing the net assimilation rate and biomass accumulation in C_3 crops.

55. (B) It provides ATP and carbon skeletons for growth
Dark respiration is a vital metabolic process that occurs continuously in plants. It oxidizes synthesized carbohydrates to generate adenosine triphosphate and reducing power, which drive growth, maintenance, and nutrient transport. Additionally, this process produces intermediate carbon skeletons that serve as precursors for synthesizing essential proteins, lipids, and structural cell wall components.

56. (A) 2, 3, 1
Water-use efficiency varies across photosynthetic pathways. CAM crops exhibit the highest efficiency because they open stomata at night when evaporative demand is low. C_4 crops are the next most efficient, using a carbon-concentrating mechanism to keep stomata partially closed during the day. C_3 crops are the least efficient, requiring larger stomatal openings for carbon uptake.

57. (B) 4–6%
The maximum theoretical solar energy conversion efficiency of terrestrial C_3 plants is limited to approximately four to six percent. This thermodynamic limit is imposed by several factors, including the narrow spectrum of photosynthetically active radiation, light reflection and transmission, activation energy requirements, and carbon losses from photorespiration and respiration.

58. (A) $RWC = \dfrac{(\text{Fresh Weight} - \text{Dry Weight})}{(\text{Turgid Weight} - \text{Dry Weight})} \times 100$
Relative Water Content is a physiological index used to evaluate the water status of crop leaves. It is calculated by dividing the difference between leaf fresh weight and dry weight by the difference between leaf turgid weight and dry weight, expressed as a percentage. This metric reflects the hydration level of leaf tissues.

59. (B) Decreases conductance and reduces transpiration
Elevated atmospheric carbon dioxide concentrations trigger stomatal closure in both C_3 and C_4 crop species. Guard cells respond to high internal carbon dioxide levels by reducing stomatal aperture, which decreases stomatal conductance. This physiological response reduces transpiration rates, helping to improve crop water-use efficiency under changing environmental conditions.

60. (B) It evaluates crop responses in natural, open-field conditions
The Free-Air CO_2 Enrichment system releases carbon dioxide into open fields to maintain elevated concentrations over a crop canopy without structural enclosures. This approach avoids microclimatic artifacts like altered temperature, humidity, and wind flow typical of greenhouses, allowing researchers to study

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realistic crop and ecosystem responses under natural field conditions.

61. (A) Carbon assimilation to transpirational water loss
Crop water-use efficiency is defined as the ratio of biomass produced or carbon dioxide assimilated to the volume of water lost through transpiration. This physiological index quantifies how efficiently a crop uses available water resources to synthesize dry matter, serving as a key trait for breeding drought-tolerant cultivars.

62. (C) Upregulation of cellular antioxidant enzymes
Abiotic stresses lead to the overproduction of reactive oxygen species, which cause cellular damage. To prevent oxidative damage to lipids, proteins, and nucleic acids, plants upregulate genes that encode antioxidant enzymes. These enzymes, including superoxide dismutase, catalase, and ascorbate peroxidase, scavenge and detoxify harmful oxygen species within cells.

63. (D) Compatible solutes like proline and glycine betaine
Osmotic adjustment is an adaptation to water deficit. It involves the accumulation of non-toxic, low-molecular-weight compatible solutes, such as proline, glycine betaine, and soluble sugars, within the cytoplasm. These solutes lower cellular osmotic potential, helping to maintain turgor pressure and cell volume to support metabolic activity under dry conditions.

64. (C) Osmotic effects reducing root water uptake
High salt concentrations in the soil solution lower the external osmotic potential, making it difficult for root systems to absorb water. This osmotic effect causes an immediate reduction in crop growth rate that mimics drought stress, leading to stomatal closure, reduced leaf expansion, and lower photosynthetic activity before salts accumulate to toxic levels.

65. (B) Formation of adventitious roots and aerenchyma
Soil waterlogging limits oxygen diffusion, causing root hypoxia. This stress triggers a rapid increase in the synthesis of the gaseous phytohormone ethylene within submerged tissues. Ethylene accumulation promotes cellulase activity, leading to cortical cell collapse that forms aerenchyma and stimulates the development of adventitious roots to restore oxygen and nutrient uptake.

66. (D) Electromagnetic waves
Remote sensing in agriculture is based on detecting and analyzing electromagnetic waves reflected or emitted by crop canopies and soils. Sensors mounted on satellites, aircraft, or drones measure radiation across various wavebands, such as visible, near-infrared, and thermal infrared, to evaluate crop health, canopy structure, and water status.

67. (A) Low reflectance in the visible red band and high reflectance in the near-infrared band
Healthy, growing crop vegetation displays a characteristic spectral signature. Chlorophyll pigments absorb heavily in the visible red band to power photosynthesis, resulting in low reflectance. Meanwhile, the cellular structure of healthy leaf mesophyll tissues scatters and reflects near-infrared radiation, producing high reflectance in that band.

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68. (C) $NDVI = \dfrac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$
The Normalized Difference Vegetation Index is a standard index used to monitor crop canopy growth and vigor. It is calculated by dividing the difference between near-infrared and red reflectance by their sum. This normalization outputs values ranging from negative one to positive one, with high positive values indicating dense, green vegetation.

69. (A) Bare soil reflectance in sparse fields
In sparse crops, background soil reflectance can distort vegetation index values. The Soil Adjusted Vegetation Index addresses this issue by introducing a soil-calibration factor into the standard index equation. This adjustment factor minimizes soil background noise, providing a more accurate estimation of green leaf area in fields with low canopy cover.

70. (D) Transpirational cooling
Infrared thermometry estimates crop water status by measuring canopy temperature. Under adequate soil moisture, open stomata facilitate high transpiration rates, which cools the leaves below ambient air temperature. When water is scarce, stomata close to conserve moisture, reducing this transpirational cooling and causing canopy temperature to rise noticeably.

71. (B) Fully transpiring and non-transpiring baselines
The Crop Water Stress Index is calculated by scaling the measured canopy-to-air temperature difference against two baseline limits. The lower limit represents a fully transpiring crop with open stomata, while the upper limit represents a non-transpiring canopy with closed stomata under maximum stress. This scaling provides an index of water deficit.

72. (B) I and III
Net Primary Productivity can be estimated through sequential biomass harvesting, which measures dry matter accumulation over time. The eddy covariance technique provides a continuous micrometeorological measurement of net carbon dioxide exchange. However, Gross Primary Productivity is always higher than Net Primary Productivity because GPP represents the total carbon fixed before respiratory losses.

73. (D) Ambient temperature
Ambient temperature is the primary driver of crop phenological development. Biochemical reactions, cell division, and tissue differentiation are temperature-dependent processes. The rate at which a crop progresses through vegetative and reproductive stages is determined by the accumulation of thermal units above a base temperature, rather than soil chemical or structural factors.

74. (A) The threshold temperature below which crop development ceases
The base temperature is a physiological constant specific to each crop species. It represents the lowest temperature threshold at which metabolic activity and developmental processes can occur. Below this temperature, crop growth and development halt, and any heat accumulation is excluded from thermal time calculations like Growing Degree Days.

75. (B) Wild relatives and genetic diversity of the crop
Vavilovian centers of origin are characterized by high genetic diversity within a cultivated plant species and the presence of its wild ancestors. These geographic regions served as the original locations of domestication, preserving gene pools that are valuable for modern crop breeding programs seeking pest resistance and stress tolerance traits.

76. (B) Precipitation and potential evapotranspiration
The Length of Growing Period defines the continuous period during the year when rainfall and soil moisture reserves exceed half of the potential evapotranspiration. This metric determines the duration available for crop growth without severe water stress, serving as a primary criterion for classifying agro-climatic zones and planning cropping systems.

77. (A) Nikolai Vavilov
Nikolai Vavilov formulated the Law of Homologous Series in Variation. This genetic principle states that closely related species and genera share similar patterns of heritable variation. By studying the traits present in one crop species, scientists can predict and locate corresponding genetic variations in related species, accelerating germplasm discovery.

78. (C) Vernalization
Vernalization is the physiological process where exposure to a prolonged period of low temperature during the vegetative stage is required to trigger flowering. This cold requirement ensures that winter crops, such as winter wheat, do not initiate flowering before winter, delaying reproductive development until favorable spring conditions arrive.

79. (D) Reduced transpiration and increased crop WUE
Elevated carbon dioxide levels cause stomata to partially close, reducing stomatal conductance. This physiological response restricts the outward diffusion of water vapor from the leaves, lowering transpiration rates. Because carbon dioxide assimilation remains high, the ratio of carbon fixed to water lost increases, improving crop water-use efficiency.

80. (B) I, II and III
C_4 plants possess Kranz anatomy and exhibit low photorespiration rates compared to C_3 plants. CAM plants conserve water by opening their stomata primarily at night. However, C_4 plants do not fix carbon dioxide initially into a three-carbon acid; they use PEP carboxylase to fix it into a four-carbon compound, oxaloacetate.

81. (B) Grain filling
Terminal heat stress is highly damaging to wheat when it occurs during the grain-filling stage. High temperatures during this phase accelerate

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leaf senescence, shorten the grain-filling period, and reduce starch synthesis. This disruption leads to shriveled grains, lower individual kernel weight, and a significant decrease in final grain yield.

82. (D) It involves horizontal advection of cold air masses
Advection frost is caused by the horizontal movement of a cold, dry air mass into an agricultural region. Unlike radiation frost, which develops on calm, clear nights due to radiative cooling of the soil and canopy, advection frost is accompanied by moderate to high winds and can occur during either day or night.

83. (A) Overhead sprinkler irrigation during freezing
Overhead sprinkler irrigation protects crops from frost by utilizing the high specific heat capacity and latent heat of fusion of water. As irrigated water coats plant tissues and freezes, it releases latent heat to its surroundings. This process maintains the plant temperature at or near freezing, protecting delicate tissues from sub-zero damage.

84. (C) Phytochrome
Phytochrome is a photoreceptive pigment that regulates photoperiodic responses in crops. It exists in two interconvertible forms, absorbing red and far-red light. By sensing the ratio of these wavelengths, phytochrome detects day length and seasonal changes, signaling the plant to transition from vegetative growth to reproductive development.

85. (A) Non-photochemical quenching
Non-photochemical quenching is a crucial physiological photoprotective mechanism. When plants absorb more light energy than they can use for photosynthesis, this pathway dissipates the excess excitation energy safely as thermal energy. This prevents the formation of reactive oxygen species and protects the photosynthetic machinery from photoinhibitory damage.

86. (D) Epicuticular wax and trichomes
Epicuticular wax and epidermal trichomes increase the albedo of crop leaves. By reflecting a higher fraction of incident solar radiation, these structures reduce leaf light absorption and heat load. This morphological adaptation helps lower leaf temperature and transpirational demand, protecting the photosynthetic apparatus under intense sunlight and dry conditions.

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87. (B) Abscisic acid (ABA)
Under drought stress, roots and leaves synthesize abscisic acid, which is transported through the vascular system to guard cells. ABA triggers ion efflux from guard cells, reducing their turgor pressure. This rapid response causes stomata to close, minimizing transpirational water loss and helping to preserve plant water status during dry periods.

88. (A) I, III and IV
Malondialdehyde content is a marker of lipid peroxidation in cell membranes, while proline acts as a compatible osmolyte. Dehydrins are proteins that accumulate to protect cellular structures during dehydration. However, superoxide dismutase activity typically increases to scavenge radicals, and relative water content decreases under drought stress, validating the specified statements.

89. (D) Electrical Conductivity (EC)
Soil salinity is quantified by measuring the electrical conductivity of a saturated soil paste extract. Because dissolved salts conduct electricity, the electrical conductivity of the solution is directly proportional to its total soluble salt concentration, serving as a standard index to evaluate salinity hazards in agricultural soils.

90. (A) Unmanned Aerial Vehicle (UAV / Drone)
Unmanned aerial vehicles offer high temporal resolution for agricultural monitoring. Unlike satellites, which are limited by fixed orbital revisit schedules and cloud cover, drones can be deployed on demand to capture real-time, high-resolution imagery. This allows rapid detection and monitoring of localized crop water stress within a single field.

91. (B) It records data in narrow, contiguous bands
Hyperspectral remote sensing differs from multispectral systems by collecting data in numerous narrow, contiguous spectral bands across the electromagnetic spectrum. This high spectral resolution produces a continuous reflectance curve for each pixel, allowing the detection of subtle physiological changes, nutrient deficiencies, and specific pigment concentrations in crops.

92. (B) Red and Near-Infrared
The red edge is the region of rapid change in green vegetation reflectance, located between the red and near-infrared wavelengths. In this band, chlorophyll absorption drops, and internal leaf scattering increases. The position and slope of this transition are sensitive indicators of canopy chlorophyll concentration and leaf area index.

93. (A) Critical LAI
The critical leaf area index is defined as the specific canopy density that intercepts ninety-five percent of incident photosynthetically active radiation. Beyond this threshold, adding more leaf area does not significantly increase crop growth rate, as the lower leaves become heavily shaded and contribute more to respiration than to photosynthesis.

94. (D) 8.0 to 14.0 μm
The thermal infrared band used to measure canopy temperature lies in the eight to fourteen micrometer range. This spectral window corresponds to peak thermal emission from terrestrial surfaces at environmental temperatures. It avoids major atmospheric absorption bands, allowing accurate measurements of surface temperature to assess crop water stress.

95. (D) Water stress and stomatal closure
A negative canopy temperature depression indicates that the crop canopy is warmer than the surrounding air. This condition occurs when water stress induces stomatal closure, reducing transpirational cooling. Without the cooling effect of transpiration, sensible heat accumulates within the leaves, causing canopy temperature to rise above ambient air temperature.

96. (A) Both A and R are true and R is the correct explanation of A.
As a crop canopy matures and reaches its maximum leaf area index, the net assimilation rate typically declines. This reduction occurs because mutual shading of lower leaves limits their light interception, reducing photosynthesis. Meanwhile, these shaded tissues continue to respire, increasing total canopy respiration relative to gross carbon assimilation.

97. (B) The moles of CO_2 fixed or O_2 evolved per mole of photons absorbed
The quantum yield of photosynthesis is a measure of light-use efficiency. It is defined as the moles of carbon dioxide fixed or oxygen evolved per mole of light photons absorbed by photosynthetic tissues. This metric reflects the efficiency of the light reactions in converting absorbed light energy into chemical energy.

98. (D) A high concentration of CO_2 around RuBisCO in bundle sheath cells
In C_4 plants, initial carbon fixation in mesophyll cells is spatially separated from the Calvin cycle in bundle sheath cells. Decarboxylation of four-carbon acids in the bundle sheath releases carbon dioxide, concentrating it around RuBisCO. This high local concentration suppresses the oxygenase activity of RuBisCO, minimizing photorespiration and energy losses.

99. (A) 3-Phosphoglycerate (3-PGA)
In the C_3 photosynthetic pathway, the initial carbon fixation step is catalyzed by the enzyme RuBisCO. This enzyme carboxymethylates the five-carbon acceptor ribulose-1,5-bisphosphate to produce an unstable intermediate, which immediately splits into two molecules of the three-carbon compound 3-phosphoglycerate, the first stable product of this biochemical pathway.

100. (C) Drought stress
The initial phase of salinity stress is dominated by osmotic effects, where high salt concentrations in the soil lower water potential. This osmotic barrier restricts root water uptake, inducing water deficit symptoms that are nearly identical to drought stress, including reduced cell expansion, stomatal closure, and decreased leaf transpiration.

101. (A) Drought escape
Drought escape is an adaptive strategy where plants complete their life cycle before soil moisture is depleted. These crops exhibit rapid vegetative growth and early flowering, allowing them to produce seeds and reach physiological maturity before the onset of seasonal drought, avoiding severe dry periods entirely.

102. (D) Sequestration of ions into vacuoles
Halophytes tolerate saline environments by preventing sodium and chloride ion toxicity in the cytoplasm. They use active transport

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proteins to sequester these toxic ions into the central vacuole. This compartmentalization prevents enzyme inhibition in the cytoplasm while lowering cellular water potential to facilitate water absorption from salty soils.

103. (B) Quiescence, conserving energy until water recedes
Rice cultivars carrying the Sub1A gene exhibit submergence tolerance via a quiescence strategy. Under complete flooding, these plants suppress gibberellin-mediated stem elongation and downregulate carbohydrate metabolism. This conserves energy reserves and prevents plant exhaustion, allowing the crop to survive underwater for up to two weeks until floodwaters recede.

104. (A) P-2, Q-3, R-4, S-1
According to Vavilovian centers of origin, potato originated in the South American Andean region, and soybean developed in the Chinese center. Sorghum is native to the African center of diversity, while wheat originated in the Near East, mapping each of these major crop species to its primary geographic center of origin.

105. (D) Leaf Area Index (LAI)
The leaf area index can be estimated indirectly by inverting the Beer-Lambert Law using light transmission measurements. By measuring the fraction of photosynthetically active radiation that penetrates the crop canopy and reaches the soil surface, mathematical models can calculate the cumulative leaf area required to cause that level of light attenuation.

106. (D) Enhanced Vegetation Index (EVI)
EVI is designed to optimize the vegetation signal with improved sensitivity in high biomass regions. It minimizes canopy background scattering and atmospheric influences by incorporating blue reflectance. Unlike NDVI, which tends to saturate over dense vegetation, this index maintains sensitivity to variations in canopy structure, making it superior for monitoring dense crop canopies.

107. (A) Shortwave Infrared (SWIR)
The shortwave infrared spectral band is highly absorbed by liquid water within plant leaves, whereas near-infrared light is strongly reflected. The normalized difference water index utilizes both of these bands to monitor liquid water content in vegetation. Combining these wavelengths enables sensitive detection of canopy water stress, which is critical for irrigation management and crop health assessments.

108. (B) Generate internal energy to acquire data regardless of light or cloud cover
Active remote sensing systems, such as radar and lidar, supply their own source of electromagnetic radiation to illuminate targets. This independent energy generation allows these sensors to acquire data continuously during day or night. Because these wavelengths can penetrate clouds and rain, active systems provide reliable agricultural monitoring under adverse weather conditions that limit passive optical sensors.

109. (B) Chlorofluorocarbons (CFCs)
Chlorofluorocarbons are synthetic industrial compounds that are entirely anthropogenic in origin, meaning they have no natural sources. While biogenic methane, nitrous oxide, and carbon dioxide are naturally produced or cycled through soil processes and biological activity in agricultural ecosystems, these halogenated gases are manufactured solely for cooling, solvents, and aerosol propellants, making them unique global warming agents.

110. (A) Anaerobic, highly reduced soil conditions
Lowland paddy cultivation involves prolonged flooding of fields, which blocks the diffusion of atmospheric oxygen into the soil. This exclusion of oxygen leads to anaerobic, highly reduced soil conditions. Under these specific oxygen-depleted circumstances, specialized anaerobic microorganisms called methanogens actively break down organic matter, producing significant quantities of methane gas as a byproduct of their metabolic pathways.

111. (C) Methanogenic archaea species
Enteric fermentation in livestock is a natural digestive process occurring in the rumen, where feed is fermented by symbiotic microorganisms. Among these, methanogenic archaea species are uniquely responsible for utilizing hydrogen and carbon dioxide produced during fermentation to synthesize methane gas. This metabolic process helps maintain a low hydrogen partial pressure, which is essential for rumen digestive efficiency.

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112. (C) A is true but R is false.
Intercropping legumes with cereals is an established ecological strategy to optimize resources because legumes fix atmospheric nitrogen, benefiting both crops. However, these crop types do not share identical ecological niches. Instead, they occupy complementary spatial and temporal niches, with different root depths and growth durations, which reduces direct competition and improves overall resource use efficiency in agro-ecosystems.

113. (C) Apples, saffron, and temperate vegetables
The Western Himalayan Region covers Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, characterized by steep terrains, cool alpine conditions, and temperate climates. This agro-climatic zone is highly suitable for cultivating specialized high-value crops like apples, saffron, and temperate vegetables. These crops rely on cold temperature regimes, distinct winter dormancy, and specific seasonal rainfall patterns found in this zone.

114. (B) The functional range of environmental conditions and resources a crop utilizes
In crop ecology, the ecological niche refers to the complex of environmental variables, resource availability, and functional roles that a crop species occupies within an ecosystem. It goes beyond the physical habitat to include how the plant responds to temperature, nutrients, water, and biological interactions, defining the conditions under which it can survive, grow, and reproduce.

115. (D) Pearl millet — High temperatures
Pearl millet is highly adapted to arid and semi-arid regions and has outstanding heat tolerance, making high temperatures a favorable condition rather than a limiting constraint. Conversely, sugarcane is restricted by frost, tea is sensitive to waterlogging as it requires well-drained acid soils, and jute demands abundant moisture and suffers under dry or low rainfall conditions.

116. (A) Destruction of the apical meristem leading to severe developmental stunting
During the early vegetative stage of crop growth, high-temperature anomalies like heat waves cause severe damage to fragile tissues. The apical meristem, which coordinates shoot development, is highly sensitive to extreme heat. Thermal stress can lead to the destruction of these active cells, permanently stunting crop growth by limiting leaf production, branching capacity, and overall development.

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117. (C) Wind velocity, thereby reducing boundary layer conductance and crop transpiration
Windbreaks and shelterbelts function as mechanical barriers that reduce wind velocity across the adjacent agricultural field. By slowing wind speeds, these structures stabilize the humid boundary layer of air surrounding the crop canopy. This microclimatic adjustment reduces the vapor pressure deficit near leaf surfaces, decreasing excessive transpiration rates and significantly lowering water stress in cultivating crops.

118. (A) Nitrate reduction to ammonium requires metabolic reducing power before amino acid synthesis
For a crop plant to assimilate nitrogen, it must ultimately convert inorganic forms into organic amino acids. When nitrate is absorbed, it requires two sequential, energy-intensive reduction steps to form ammonium, catalyzed by nitrate and nitrite reductases. This biochemical conversion consumes substantial metabolic reducing power, making nitrate assimilation energetically more expensive than utilizing pre-reduced ammonium.

119. (D) A lower light compensation point and a higher specific leaf area metric
Shade-adapted leaves possess distinct physiological and anatomical characteristics designed to maximize light capture in low-radiation environments. They typically exhibit a lower light compensation point, allowing them to achieve net photosynthesis under weak light conditions. Additionally, they have a higher specific leaf area, producing thinner, wider leaves to intercept solar radiation efficiently with minimal structural carbon investment.

120. (B) P-2, Q-1, R-4, S-3
Different crop physiological parameters are measured using specific standard SI units. Photosynthetically active radiation is quantified as micromoles of photons per square meter per second. Stomatal conductance is expressed in moles per square meter per second. Net assimilation rate represents dry mass accumulation as grams per square meter per day, and transpiration rate is measured as millimoles of water.

121. (C) Transpirational pull of water through the xylem vascular bundle
The vapor pressure deficit measures the difference between the moisture level of saturated air and the actual moisture content in the atmosphere. A higher atmospheric deficit creates a strong evaporative demand on the leaves. This gradient drives the transpirational pull, drawing water continuously from the soil, through root and xylem tissues, and out through open stomata.

122. (D) Closing partially or fully to prevent catastrophic hydraulic failure
At high atmospheric vapor pressure deficits, the rate of water loss from leaves can far exceed the rate of water uptake by roots. To prevent excessive dehydration and catastrophic hydraulic failure, such as xylem cavitation, plants respond by partially or fully closing their stomatal pores, regulating transpiration and maintaining cellular turgor under dry air.

123. (A) Increasing applications of a limiting growth factor (e.g., nitrogen fertilizer)
The Law of Diminishing Returns, mathematically represented by Mitscherlich, describes how crop yields respond to incremental inputs of a limiting growth factor. Initially, each added unit of the limiting factor, like nitrogen fertilizer, yields a substantial growth increase. However, as the overall supply of this nutrient approaches sufficiency, the rate of yield improvement progressively decreases.

124. (B) Cell expansion and leaf elongation
Cell expansion and leaf elongation are highly sensitive physical processes that depend heavily on the maintenance of positive cellular turgor pressure. This internal hydrostatic pressure exerts force against the cell wall, enabling stretch and growth of newly formed cells. When turgor declines due to water deficits, cell elongation ceases, restricting leaf expansion and canopy development.

125. (B) Autecology relies exclusively on global climate models.
Autecology is the study of the relationship between an individual species or organism and its environment, focusing on physiological responses, life history, and environmental requirements. It does not rely exclusively on global climate models. In contrast, synecology investigates community dynamics, species interactions, food webs, and successional stages among co-occurring organisms in a shared habitat.

126. (A) High subsidies of auxiliary energy, nutrients, and intensive human regulation
A crop ecosystem is a highly managed agricultural system that differs from a natural ecosystem through substantial human intervention. It requires significant subsidies of auxiliary energy, such as fossil fuels, irrigation water, machinery, and external nutrient applications. These interventions alter natural successional pathways, decrease structural biodiversity, and disrupt self-regulating nutrient cycles to maximize targeted food production.

127. (C) Radiation use efficiency
Radiation use efficiency is a fundamental crop physiological metric defined as the ratio of dry matter accumulated to the total amount of photosynthetically active radiation intercepted by the canopy. This value reflects how effectively a crop plant converts absorbed light energy into biochemical energy, driving dry biomass production under specific agronomic conditions.

128. (A) 2, 4, 1, 3
The C_4 photosynthetic pathway begins with the fixation of carbon dioxide by phosphoenolpyruvate carboxylase in the mesophyll cells. The resulting malate is then transported to the bundle sheath cells, where it undergoes decarboxylation to release carbon dioxide. Finally, this concentrated carbon dioxide is refixed by the enzyme RuBisCO in the Calvin-Benson cycle of bundle sheath cells.

129. (C) Hydrogen peroxide and molecular oxygen
Superoxide dismutase is an essential antioxidant enzyme that protects plant cells from reactive oxygen species during environmental stress. This enzyme catalyzes the dismutation of highly reactive superoxide radicals into hydrogen peroxide and molecular oxygen. Subsequent enzymes, such as catalase and peroxidases, then convert the generated hydrogen peroxide into harmless water, preventing oxidative cell damage.

130. (B) Maintenance respiration, depleting valuable carbon reserves
Elevated temperatures during the night significantly accelerate the metabolic processes of plant tissues. This temperature rise directly increases cellular maintenance respiration rates,

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forcing the plant to consume carbohydrates synthesized during the day. By depleting these valuable carbon reserves instead of directing them toward grain filling or growth, high night temperatures lead to reduced crop yields.

131. (D) The ratio of reflected shortwave radiation to incoming shortwave solar radiation
In agrometeorology, albedo represents the shortwave reflective power of a surface, calculated as the ratio of reflected shortwave radiation to the total incoming solar radiation. Values range from zero to one. This parameter is highly critical because it dictates how much solar energy is absorbed by the soil or crop canopy, directly influencing the local energy balance.

132. (A) Lower albedo and faster warming
Soils rich in organic matter possess a darker surface color, which significantly lowers their shortwave albedo. This darker surface absorbs a greater proportion of incoming shortwave solar radiation instead of reflecting it. Consequently, these organic-rich soils experience faster heating and warm up more rapidly than light-colored, sandy soils under similar solar radiation conditions.

133. (C) Arid and semi-arid tropics
Crops originating in arid and semi-arid tropics have evolved deep and extensive root systems as a critical adaptation for survival. These extensive roots allow plants to tap into water reserves stored in deeper soil layers when upper soil horizons dry out. This root architecture helps maintain plant water status and continuous transpiration during prolonged drought periods.

134. (A) CAM pathway
Crassulacean Acid Metabolism represents the most water-efficient method of carbon fixation. Plants utilizing this pathway open their stomata exclusively at night when temperatures are cool and humidity is high, minimizing transpirational water loss. They temporarily store fixed carbon as malic acid, then decarboxylate and refix it during the day while stomatal pores remain completely closed.

135. (C) 500
The transpiration ratio represents the mass of water transpired by a crop plant divided by the mass of dry matter produced. When a C_3 crop requires five hundred grams of water to produce one gram of dry matter, the ratio is calculated directly as five hundred. This ratio highlights the water cost associated with dry mass accumulation.

136. (A) 2, 1, 3
The photorespiratory carbon oxidation cycle is a complex metabolic pathway that coordinates reactions across three distinct organelles. The process is initiated in the chloroplast with the oxygenase activity of RuBisCO. The intermediate products are then transported into the peroxisome, and subsequently move into the mitochondrion, where glycine is converted to serine, releasing carbon dioxide.

137. (C) Abscisic Acid (ABA)
Abscisic acid is a critical plant hormone responsible for inducing and maintaining seed dormancy. It prevents premature germination under unfavorable conditions. Upon exposure to environmental triggers like low-temperature stratification, endogenous abscisic acid levels decrease rapidly, while gibberellic acid synthesis increases, shifting the hormonal balance to promote seed germination and break natural embryo dormancy.

138. (D) Net photosynthesis is halted due to enzyme denaturation and membrane failure
The parameter designated as T_{max} in plant thermal biology represents the upper critical temperature threshold for survival. At this extreme temperature level, the vital biochemical machinery of cells completely collapses. Critical photosynthetic enzymes, particularly RuBisCO and light-harvesting proteins, undergo irreversible denaturation, while thylakoid membranes lose structural integrity, completely halting net carbon assimilation.

139. (A) Synthetic Aperture Radar (SAR)
Synthetic aperture radar is categorized as an active remote sensing platform because it emits its own microwave pulses to illuminate Earth's surface. It measures the backscattered signal reflected from targets, operating independently of solar light. This distinguishes it from passive sensors, which rely on reflected sunlight or thermal radiation emitted naturally from Earth.

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140. (B) Microwaves are highly sensitive to the dielectric constant of water
Microwave remote sensing is highly valuable for evaluating agricultural soil moisture due to its sensitivity to the dielectric constant. Liquid water has a dielectric constant of eighty, which is much higher than dry soil particles. Consequently, even slight changes in soil water content significantly affect the soil's dielectric properties, modifying the reflected microwave backscatter.

141. (C) 700 nm
The transition wavelength from visible red light to near-infrared light is approximately seven hundred nanometers. This boundary is ecologically significant because plants absorb visible red light for photosynthesis while strongly reflecting near-infrared wavelengths. This sharp reflectance transition, known as the red edge, is used in remote sensing to calculate key vegetation indices.

142. (A) Osmotic adjustment and increased root-to-shoot allocation ratio
When crops acclimate to slowly developing drought stress, they trigger complex physiological adaptations. First, plants accumulate organic and inorganic solutes, lowering cell osmotic potential to maintain positive turgor pressure. Concurrently, they allocate more carbon resources to the root system relative to the shoot, enhancing water extraction capacity from deeper soil profiles.

143. (C) Net incident solar radiation
Net incident solar radiation is the primary environmental parameter driving potential transpiration from a fully wetted crop canopy. Solar radiation provides the fundamental energy required to convert liquid water in leaves into water vapor, representing the latent heat of vaporization. Under well-watered conditions, this radiation governs atmospheric demand and canopy water loss.

144. (A) I and II
Net assimilation rate is a physiological index measuring the net increase in dry matter per unit leaf area over a specific time. It represents the balance between carbon gain via photosynthesis and carbon loss through plant respiration. This rate is not constant but declines continuously as the crop matures due to self-shading and aging tissues.

145. (C) C_4 crops require significantly less RuBisCO enzyme to achieve high photosynthetic rates
C_4 crops exhibit higher nitrogen use efficiency than C_3 crops because of their unique carbon-concentrating mechanism. This mechanism elevates carbon dioxide levels around the enzyme RuBisCO, minimizing energy-wasting photorespiration. Consequently, C_4 plants require substantially lower concentrations of RuBisCO to maintain high photosynthetic rates, allowing them to allocate less leaf nitrogen to this massive enzyme.

146. (B) Manganous ($Mn^{\{2+\}}$) and ferrous ($Fe^{\{2+\}}$) ions
Waterlogging creates saturated, anaerobic conditions that rapidly deplete soil oxygen. Under this low redox potential, anaerobic soil microorganisms use alternative electron acceptors, reducing oxidized compounds. This biochemical process converts insoluble manganese and iron oxides into soluble, reduced manganous and ferrous ions. These ions accumulate quickly in the soil solution, reaching levels toxic to crops.

147. (D) Emissivity
To measure the absolute surface temperature of a crop canopy using infrared thermometry, knowing canopy emissivity is essential. Emissivity measures the efficiency of a surface in emitting thermal energy compared to a perfect blackbody. Without precise calibration for emissivity, measured thermal radiation values cannot be converted accurately into absolute canopy temperatures.

148. (A) Fourth power of its absolute temperature
The Stefan-Boltzmann law states that the total thermal energy radiated per unit surface area of a blackbody is directly proportional to the fourth power of its absolute thermodynamic temperature. In agrometeorology, this physical principle allows thermal sensors to estimate crop canopy or soil temperatures based on the intensity of longwave infrared radiation emitted by those surfaces.

149. (C) Entering stomata and generating severe oxidative stress in the mesophyll
Tropospheric ozone behaves as a highly toxic air pollutant for agricultural crops. It enters leaves through open stomata during normal gas exchange. Once inside the substomatal cavity, ozone reacts with cellular components,

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generating highly reactive oxygen species. These radicals cause oxidative stress in the mesophyll, damaging chloroplasts, inhibiting photosynthesis, and leading to yield losses.

150. (A) Maize
Maize is a tropical crop that serves as a classical physiological model for studying chilling injury. Unlike temperate crops, maize is highly sensitive to non-freezing low temperatures. Exposure to temperatures below ten degrees Celsius disrupts membrane lipids, inhibits photosynthetic enzymes, and impairs water uptake, providing researchers with clear visual and metabolic indicators of chilling stress.

151. (D) Dehydration
Freezing injury in crop plants occurs when ice crystals form within plant tissues, typically starting in extracellular spaces. As extracellular water freezes, it lowers the external water potential, drawing liquid water out of the cell cytoplasm. This continuous efflux of water causes severe intracellular dehydration, membrane disruption, and eventual collapse of the living cell structure.

152. (A) I and II
The crop water stress index ranges from zero, representing no water stress with maximum transpiration, to one, representing complete stress with fully closed stomata. Calculating this index requires measuring canopy temperature along with ambient air temperature and vapor pressure deficit. This combination provides a standardized assessment of crop water status under varying environmental conditions.

153. (C) Stomatal resistance (r_s)
Stomatal conductance measures the rate of gas exchange through leaf stomatal pores, representing the ease with which carbon dioxide and water vapor pass. Mathematically, conductance is defined as the reciprocal of stomatal resistance. Therefore, as resistance to gas diffusion increases due to stomatal closure, stomatal conductance decreases proportionally, showing an inverse relationship.

154. (D) Multiple suboptimal biotic and abiotic factors interact dynamically throughout the season
In open-field agriculture, crops are exposed to complex, fluctuating field conditions. The theoretical genetic maximum yield is rarely achieved because multiple limiting factors, such as unpredictable weather, localized drought, soil nutrient heterogeneities, and pest pressures, occur simultaneously. These suboptimal factors interact dynamically over the growing season, reducing physiological efficiency and final crop productivity.

155. (A) Adjusting crop plant density and row spacing
Adjusting crop plant density and row spacing is a highly effective agronomic management practice to alter early-season leaf area index. By manipulating spatial distribution and plant populations, growers optimize light interception, accelerate ground cover closure, and reduce weed competition. This physical restructuring influences the canopy microclimate, maximizing photosynthetically active radiation capture.

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156. (B) Significant yield reduction due to accelerated phenology and terminal heat stress
In the Indo-Gangetic plains, a projected rise of two degrees Celsius in mean temperature accelerates wheat development, reducing the grain-filling duration. This rapid progression through phenological stages limits dry matter accumulation. Concurrently, elevated temperatures induce terminal heat stress during grain development, leading to floret sterility, smaller grain size, and significant yield reductions.

157. (B) An uninterrupted dark period exceeding a critical length
Photoperiodism in short-day plants is regulated by the duration of continuous darkness. Rather than responding to short light periods, these plants require an uninterrupted dark phase that exceeds a specific critical threshold to induce flowering. Even a brief flash of light during this dark phase can disrupt the signaling pathway, preventing the floral transition.

158. (A) Short-day plant
Soybean is widely classified as a short-day plant in terms of its photoperiodic requirements for floral initiation. It requires long, uninterrupted nights to trigger the biochemical pathways that transition the plant from vegetative to reproductive growth. Although cultivars vary in environmental sensitivity, short-day conditions are generally necessary to promote timely flowering and crop maturity.

159. (C) Minimizing heat load and photoinhibition by orienting parallel to solar rays
Under water-limited conditions, crops like soybean and cotton exhibit heliotropic movements to regulate light interception. Specifically, they orient their leaves parallel to incoming solar rays, a phenomenon known as diaheliotropism. This adjustment reduces leaf temperature, minimizes heat load, and protects the photosynthetic machinery from photoinhibition caused by excess radiation during drought stress.

160. (A) I, II, III and V
The geographic distribution of Indian crops is governed by distinct climatic requirements. Saffron is restricted to cool, temperate Kashmir. Coconut requires warm, humid frost-free coastal areas. Tea demands heavy rainfall coupled with excellent soil drainage. Cardamom thrives in the cool, shaded understory of the Western Ghats. However, pearl millet is adapted to semi-arid, not humid, zones.

161. (C) Frost and prolonged dry seasons
The commercial cultivation of the rubber tree is highly restricted by climate. This tropical species requires high year-round temperatures, consistent soil moisture, and high humidity. It is highly intolerant to frost, which causes severe cellular damage, and prolonged dry seasons, which disrupt latex flow and reduce overall physiological function, limiting cultivation to equatorial regions.

162. (B) Rainfed rice
Zone Seven, the Eastern Plateau and Hills Region of India, covers tribal and hilly areas of Chota Nagpur, Orissa, and Madhya Pradesh. It is characterized by high, variable rainfall combined with limited irrigation infrastructure. Rainfed rice is the dominant crop in this region, relying directly on monsoon precipitation and representing the primary agricultural system.

163. (D) Net carbon assimilation rate to stomatal conductance ($\frac{A}{g_s}$)
At the single leaf level, intrinsic water use efficiency is mathematically defined as the ratio of the net photosynthetic carbon assimilation rate to stomatal conductance. This ratio evaluates how much carbon dioxide is fixed per unit of stomatal opening. It provides a standardized measure of leaf efficiency in utilizing water for carbon gain under drought or normal conditions.

164. (A) Increased reflectance in the visible green and red bands due to reduced chlorophyll absorption
Severe nitrogen deficiency limits chlorophyll synthesis, leading to leaf chlorosis. Because chlorophyll is the primary pigment absorbing visible light, particularly in the blue and red bands, its reduction increases reflectance in the visible green and red regions. Consequently, the canopy reflects more visible light, indicating low photosynthetic capacity and nutrient stress.

165. (C) Rapid onset of biotic or abiotic stress causing canopy degradation
A sudden decline in the normalized difference vegetation index mid-season indicates rapid vegetative changes. Since this index tracks chlorophyll absorption and near-infrared leaf scattering, a drop reflects loss of leaf area, chlorophyll degradation, or structural canopy damage. This response is commonly triggered by sudden stresses like pest outbreaks, hail, or rapid drought onset.

166. (A) Images are captured at exactly the same local solar time, minimizing shadow variations
A sun-synchronous orbit ensures that the satellite passes over any given location on Earth at the exact same local solar time. This consistency stabilizes solar illumination geometry across sequential images. By minimizing variations in shadow length and direction, it allows researchers to accurately compare vegetation reflectance and detect crop changes over time.

167. (D) The smallest detectable area on the ground represented by a single image pixel
In remote sensing, spatial resolution defines the physical dimensions of the smallest area on Earth's surface that can be detected and resolved by a sensor. It corresponds directly to the ground area represented by a single image pixel. High spatial resolution allows for detailed mapping of small-scale agricultural features, such as individual plant rows.

168. (A) Both A and R are true and R is the correct explanation of A.
Elevated atmospheric carbon dioxide stimulates C_3 photosynthesis because the enzyme RuBisCO is not saturated under current ambient levels, and increased carbon dioxide suppresses photorespiration. In contrast, C_4 crops possess a carbon-concentrating mechanism that already saturates RuBisCO. Thus, C_3 crops exhibit a

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much stronger photosynthetic and yield response to carbon dioxide fertilization than C_4 crops.

169. (C) Storm surges inundate fields with highly saline ocean water
Cyclones induce severe secondary soil salinity in coastal agricultural areas primarily through storm surges. These events force high-velocity ocean water inland, completely inundating low-lying farming fields. As the highly saline seawater pools and subsequently evaporates, it deposits massive quantities of sodium and chloride salts on the soil surface, degrading soil structure and limiting crop productivity.

170. (D) The irradiance level beyond which further increases in light do not increase net photosynthetic rates
The light saturation point defines the specific level of incident solar radiation beyond which the rate of net photosynthesis reaches its absolute maximum. At this irradiance threshold, other biochemical processes, such as carbon dioxide diffusion or enzyme activities, become limiting. Consequently, further increases in light intensity fail to stimulate any additional carbon assimilation.

171. (A) Light levels exceeding photosynthetic dissipation capacity, causing damage to Photosystem II
Photoinhibition occurs when plants are exposed to excess light levels that exceed the energy dissipation capacity of their photosynthetic machinery. This excess excitation energy leads to the accumulation of reactive oxygen species, which damage critical proteins within Photosystem Two. Consequently, the efficiency of photosynthetic light reactions drops, reducing overall carbon assimilation and crop growth.

172. (B) Indian (Hindustan) center
The Indian mega-diversity center of origin, identified by Nikolai Vavilov, is a major geographic source of genetic diversity for many crops. This region is rich in wild relatives and landraces of crops like eggplant, pigeonpea, and black gram. Preserving this genetic reservoir is crucial for crop breeding programs addressing climate resilience.

173. (B) Growth respiration and cellular maintenance respiration
Net primary productivity represents gross primary productivity minus autotrophic respiration. This respiratory carbon loss is divided into growth respiration and maintenance respiration. Growth respiration provides the energy required to synthesize new biomass and structural tissues, whereas maintenance respiration supplies energy to maintain existing cellular integrity, repair proteins, and regulate chemical gradients.

174. (A) Structural stem tissues (straw)
Modern high-yielding cultivars, such as Green Revolution semi-dwarf wheat varieties, achieved elevated harvest indices by optimizing carbon partitioning. Specifically, they utilize dwarfing genes to redirect net primary productivity away from structural stem tissues towards developing grain structures. This physical alteration reduces lodging risks and maximizes grain yield per unit of total biomass.

175. (C) Total dry biomass divided by accumulated Growing Degree Days (GDD)
Heat unit efficiency evaluates how effectively a crop plant converts thermal energy into accumulated dry matter. It is calculated by dividing total dry biomass production by cumulative growing degree days recorded over the growing season. This metric highlights the productivity of a crop relative to the thermal time experienced during its growth period.

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176. (D) P-3, Q-4, R-1, S-2
Agricultural spectral indices serve diverse analytical functions. The normalized difference vegetation index tracks general canopy vigor and biomass. The normalized difference water index monitors leaf liquid water content. The crop water stress index integrates thermal and weather data for water stress mapping. The enhanced vegetation index tracks high-biomass canopies without experiencing structural signal saturation.

177. (C) Arrangement and geometry of leaves on the stem
Phyllotaxy defines the specific spatial arrangement and geometric patterns of leaves along a plant stem. This physical arrangement determines how leaves are positioned relative to one another, directly impacting how effectively

light penetrates the canopy. By optimizing leaf distribution, phyllotaxy minimizes self-shading, maximizes light interception, and improves overall crop photosynthetic efficiency.

178. (B) Facilitating deeper solar radiation penetration to illuminate lower canopy leaves
An erectophile canopy, characterized by vertical leaf orientations, is highly advantageous in dense crop stands. This upright orientation allows incoming solar radiation to penetrate deeper into the canopy profile, illuminating lower leaves that would otherwise be heavily shaded. This spatial distribution of light maintains photosynthetic activity across all canopy layers, boosting total productivity.

179. (D) Promote yield increases until a different factor becomes the new limiting resource
According to agricultural ecological principles, supplying the single most limiting nutrient relieves the primary constraint on growth, stimulating a yield increase. However, this growth trajectory is not infinite. As biomass accumulates, another essential environmental resource, such as water, light, or a different nutrient, is depleted and becomes the next active limiting factor restricting productivity.

180. (A) Requires an elevated saline environment to optimize growth and complete its life cycle
An obligate halophyte is biologically distinguished by its absolute requirement for elevated soil salinity to achieve optimal growth and complete its life cycle. Unlike facultative halophytes, which merely tolerate salt but grow better in fresh water, these specialized plants possess physiological mechanisms that depend on sodium ions for cellular osmotic balance and vacuolar turgor.

181. (C) It overlooks the substantial artificial energy subsidies (fertilizer, fuel) inputted by humans
The ten percent ecological law describes energy transfer efficiency between trophic levels in natural food webs. However, this model is overly simplistic for modern agro-ecosystems. Agriculture relies heavily on substantial human subsidies of auxiliary energy, including chemical fertilizers, mechanization, and irrigation. These high-energy inputs alter natural thermodynamic limits, elevating agricultural productivity beyond typical food web constraints.

182. (A) Higher photorespiration rate
C_3 crops exhibit a significantly higher rate of photorespiration than C_4 crops because of differences in their photosynthetic pathways. The primary enzyme RuBisCO can bind either carbon dioxide or oxygen. Under typical field conditions, high oxygen levels relative to carbon dioxide trigger the oxygenase activity of RuBisCO, causing substantial photorespiratory energy losses in C_3 plants.

183. (D) High latent heat of vaporization
Transpirational cooling is a vital biophysical defense mechanism protecting crop leaf tissues from high-temperature injury. This process relies on water's high latent heat of vaporization, which represents the significant energy required to convert liquid water into gas. As water evaporates from stomata, it absorbs and dissipates thermal energy from leaf surfaces, lowering canopy temperatures.

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184. (A) Both A and R are true and R is the correct explanation of A.
Flooded rice fields create strongly anaerobic soil conditions that favor methanogenic archaea, leading to high methane emissions. Implementing alternate wetting and drying periodically drains fields, introducing atmospheric oxygen into the soil. This aeration inhibits strictly anaerobic methanogenic activity, while promoting methane-oxidizing bacteria, which significantly reduces overall methane release from agricultural lands.

185. (C) Positive cell turgor pressure at substantially lower tissue water potentials
Osmotic adjustment is an important physiological stress response where plant cells actively accumulate compatible solutes, such as proline or sugars. This chemical accumulation lowers cell osmotic potential, driving water influx and maintaining positive cellular turgor pressure even at low water potentials. Consequently, plants support cell growth, stomatal function, and tissue expansion during drought.

186. (D) Lignin
Under drought stress, plants adapt by reinforcing their cell walls with lignin, a complex structural polymer. Lignification increases mechanical strength and rigidity, helping tissues resist collapse under high tension. However, in forage crops, this biochemical shift decreases overall cellular digestibility and nutritional quality,

making feed less palatable and harder for ruminants to break down.

187. (A) Extract water from deep soil profiles via a vigorous taproot system
The geographical distribution and resilience of cultivated sunflower are favored by its extensive root architecture. This crop develops a deep, vigorous taproot system capable of extracting moisture and mobile nutrients from deep soil horizons. This physical capability allows sunflower plants to maintain a stable water status and sustain physiological functions during prolonged periods of dry weather.

188. (B) Minimum winter survival temperatures (winterkill)
The northern geographical boundary of commercial winter wheat cultivation is determined by absolute minimum winter temperatures. Winter wheat requires a winter dormancy period, but extreme cold can cause freezing injury or winterkill of the crown tissue. When winter survival temperatures fall below critical thresholds, crop survival declines, limiting cultivation of these winter varieties in higher latitudes.

189. (B) The ratio of precipitation to potential evapotranspiration
Bioclimate classification in agro-ecological zoning utilizes the ratio of precipitation to potential evapotranspiration as a primary moisture index. Rather than tracking simple rainfall, this ratio accounts for both water input and evaporative atmospheric demand. This standardized index accurately reflects water availability for crop development, defining boundaries of arid, semi-arid, and humid zones.

190. (A) Both deficiency and severe excess (toxicity) of a nutrient will limit crop yield
Shelford's Law of Tolerance states that crop growth is restricted not only by resource deficiency but also by environmental excess. For micronutrient management, this principle highlights that both sub-optimal deficiency and excessive concentrations can limit physiological functions. Consequently, maintaining micronutrient levels within a specific range is essential to avoid deficiency or toxicities that restrict crop yields.

191. (C) Hypoxia and suppression of aerobic root respiration
Poor soil drainage hinders the diffusion of atmospheric oxygen into the root zone, causing rapid oxygen depletion. This exclusion of gas leads directly to root hypoxia. Without sufficient oxygen, roots cannot sustain aerobic cellular respiration, restricting ATP production. This energy limitation impairs active mineral nutrient uptake, inhibits root elongation, and compromises overall plant growth.

192. (D) P-2, Q-4, R-1, S-3
Plants utilize diverse molecules to tolerate abiotic stress. Proline serves as a cellular osmoprotectant, maintaining cell volume and stabilizing macromolecules. Late embryogenesis abundant proteins act as desiccation-protection chaperones. Superoxide dismutase acts as a critical antioxidant enzyme that scavenges reactive oxygen species. Abscisic acid operates as a key signaling hormone that regulates stomatal closure.

193. (C) Spatial compartmentalization of photosynthetic enzymes
Kranz anatomy is a specialized leaf structure in C_4 plants designed for the spatial compartmentalization of photosynthetic reactions. It organizes leaves into outer mesophyll cells and inner bundle sheath cells. This anatomical division allows phosphoenolpyruvate carboxylase to capture carbon in the mesophyll, while concentrating carbon dioxide around RuBisCO in the bundle sheath, suppressing energy-wasting photorespiration.

194. (B) Leaf area to leaf dry mass
Specific leaf area is a fundamental growth analysis parameter calculated as the ratio of total leaf area to leaf dry mass. This metric indicates leaf thickness and structural density. A high value represents thin, wide leaves optimized for light interception in shaded environments, whereas a low value signifies thick, dense leaves typical of high-radiation zones.

195. (D) Total canopy dry biomass of an entire field
In agricultural ecology, physical properties can be classified as intensive or extensive. Intensive variables, such as canopy temperature, nitrogen concentration, and stomatal conductance, do not depend on system size. Conversely, total canopy dry biomass represents an extensive property, as

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its value scales directly with the physical area and total volume of the managed agricultural field.

196. (A) Ultraviolet-B (UV-B)
The depletion of stratospheric ozone, commonly termed the ozone hole, reduces the atmosphere's capacity to filter solar radiation. This allows a greater proportion of high-energy ultraviolet-B radiation to penetrate down to Earth's surface. Increased exposure to these wavelengths is highly damaging to crops, disrupting cellular structures and inhibiting basic photosynthetic pathways.

197. (C) Induction of pyrimidine dimers, resulting in severe DNA damage
Ultraviolet-B radiation causes severe physiological stress in crops by disrupting molecular components. It is absorbed by cellular nucleic acids, triggering the formation of pyrimidine dimers. This structural lesion represents severe DNA damage that halts replication and transcription processes. Unless repaired by photolyase enzymes, this genetic disruption inhibits cell division and stunting vegetative development.

198. (A) Extremely arid conditions with high daytime temperatures and low water availability
The CAM photosynthetic pathway evolved as a specialized survival adaptation for extremely arid environments. These regions are characterized by low soil moisture, high daytime temperatures, and extreme atmospheric vapor deficits. By keeping stomata tightly closed during the day and opening them exclusively at night, CAM crops minimize transpiration, maintaining high water-use efficiency under severe drought.

199. (D) Dark respiration generates useful ATP, whereas photorespiration dissipates energy without ATP
Dark respiration and photorespiration are biochemically distinct processes in crops. Dark respiration occurs in mitochondria continuously, breaking down carbohydrates to synthesize ATP and carbon skeletons. Conversely, photorespiration is light-dependent, initiated when RuBisCO binds oxygen. This pathway serves as an energy-dissipating process that recaptures some carbon but consumes energy without producing useful ATP.

200. (B) The canopy is experiencing severe water deficit, halting transpirational cooling
When a crop canopy exhibits temperatures significantly higher than the surrounding air, it indicates severe soil water deficits. Under water stress, plants close their stomata to restrict transpirational water loss. This stomatal closure halts transpirational cooling, causing incident solar radiation to heat the leaves beyond ambient air temperature. This thermal shift acts as a stress indicator.

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201. (C) Crop Growth Rate (CGR)
Crop growth rate is a key vegetative metric calculated by sequential biomass harvests over time. It represents the increase in dry matter per unit ground area per unit time. This measurement integrates overall crop performance and photosynthetic efficiency across the entire canopy, highlighting how environmental factors and management practices affect dry mass accumulation throughout the season.

202. (D) The net photosynthetic rate of leaves and the total leaf area intercepting light
The equation for crop growth rate demonstrates that productivity is governed by both structural and biochemical parameters. It multiplies net assimilation rate, which measures leaf-level net photosynthetic efficiency after accounting for respiratory losses, by leaf area index, representing the light-intercepting leaf area. Together, these factors dictate the dry matter accumulated by the canopy.

203. (A) Nitrous oxide (N_2O)
Nitrous oxide is a potent greenhouse gas emitted from agricultural soils. Its production is driven by microbial nitrification and denitrification processes, which are significantly accelerated by the application of synthetic nitrogen fertilizers and animal manure. This gas has a global warming potential nearly three hundred times greater than carbon dioxide, representing a critical target for agricultural emission mitigation.

204. (B) High humidity and rainfall during maturity trigger shattering and reduce seed quality
Isabgol is culturally and geographically restricted to the arid and semi-arid regions of Western India due to specific weather requirements. It requires cool, dry climates for development. High humidity, heavy dews, or rainfall during seed maturity trigger mucilage swelling, causing

severe seed shattering and ruining crop quality, making dry climates essential for successful cultivation.

205. (B) A poleward and upward altitudinal shift in the optimal zones for cool-season crops
Global warming is projected to shift the optimal cultivation zones for cool-season crops. As temperatures rise, traditional growing regions in lower latitudes or lower altitudes become warmer than optimal, inducing heat stress. Consequently, the suitable biophysical climate zones for these crops shift poleward to higher latitudes and upward to higher elevations where cooler temperatures persist.

206. (A) The total volume of freshwater used to produce a commodity from field to consumer
The concept of virtual water measures the total cumulative volume of freshwater consumed throughout the production chain of an agricultural commodity. This calculation incorporates all water used during crop cultivation, processing, packaging, and transportation. Tracking virtual water helps evaluate the global water footprint and the implicit trade of water resources embedded in traded goods.

207. (C) The Calvin-Benson cycle
The Calvin-Benson cycle is the universal biochemical pathway utilized by all autotrophic crop plants for carbon fixation and carbohydrate synthesis. Although C_4 and CAM crops utilize unique upstream accessory mechanisms to concentrate carbon dioxide, they ultimately direct this captured carbon to the Calvin-Benson cycle, where the enzyme RuBisCO catalyzes carbon fixation into stable organic sugars.

208. (D) One plant suppresses another via releasing biochemical toxic inhibitors
Allelopathy represents a negative biochemical interaction between plants in an ecosystem. It occurs when one plant species synthesizes and releases secondary metabolites, known as allelochemicals, into the surrounding rhizosphere or atmosphere. These toxic compounds inhibit the germination, growth, or development of neighboring plants, reducing weed competition or suppressing nearby crop species.

209. (C) Developed after domestication, yielding unique morphological variations in new climates
Secondary centers of origin represent regions where domesticated crop species underwent subsequent diversification after being introduced from primary centers. These regions contain high genetic diversity and unique morphological variations developed in response to new environmental pressures and cultivation practices. Unlike primary centers, they generally lack the wild ancestors from which the crop was initially domesticated.

210. (B) The phase and polarization of the backscattered microwave signal
Radar remote sensing evaluates the structural geometry and biomass of crop canopies by analyzing physical characteristics of the reflected signal. This active technology measures changes in the phase and polarization of backscattered microwave radiation. Different canopy structures, such as leaves, stems, and soil, depolarize and shift the phase of incoming radar waves in distinctive patterns.

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CHAPTER 02
Weed Management

2013

1. Which of the following mechanisms best defines secondary dormancy in weed seeds?
(A) Dormancy caused by an underdeveloped or immature embryo at the time of seed dispersal
(B) Dormancy resulting strictly from an impermeable, thick, and hard seed coat
(C) Dormancy genetically programmed within the seed tissue prior to shedding
(D) Dormancy induced after dispersal due to unfavorable environmental conditions

2005

2. The dissemination of weed seeds primarily through attachment to animal fur or feathers is technically termed as which of the following?
(A) Anemochory
(B) Hydrochory
(C) Epizoochory
(D) Endozoochory

2019

3. Under the standard ecological classification of weeds, which category strictly refers to plants that are native to a region but act as weeds in disturbed natural habitats?
(A) Invasive alien weeds
(B) Apophytes
(C) Noxious quarantine weeds
(D) Anthropophytes

2006

4. Which of the following statements INCORRECTLY characterizes the Critical Period of Weed Control (CPWC)?
(A) It defines the interval during which crops must be kept weed-free to prevent unacceptable yield loss.
(B) It is determined by superimposing the critical weed-free period and the critical timing of weed removal.
(C) It varies significantly based on crop species, planting density, and environmental conditions.
(D) It generally begins at the time of crop emergence and extends until crop physiological maturity.

NODIA

2023

5. Consider the following statements regarding weed calculation indices:
I. Weed Control Efficiency (WCE) evaluates the reduction in weed dry matter compared to the unweeded control.
II. Weed Index (WI) measures the percentage yield reduction due to weeds compared to the weed-free treatment.
III. The Damage Boundary represents the weed density at which the cost of control equals the expected crop value increase.
Which of the above statements is/are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I only

2006

6. If a mature crop releases volatile compounds into the atmosphere that subsequently inhibit the germination of neighboring weed seeds, this phenomenon is best classified as:
(A) Functional allelopathy via root exudation
(B) Resource competition
(C) True allelopathy via volatilization
(D) Amensalism through soil microbial alteration

2010

7. A continuous shift toward perennial weed species in a cropping system is most directly caused by which of the following agricultural practices?
(A) Long-term adoption of zero-tillage practices
(B) Continuous intensive deep moldboard plowing operations
(C) Extensive and repeated use of contact post-emergence herbicides
(D) High-density planting configurations of competitive cereal crops

2019

8. Based on chemical family classification, sulfonylureas and imidazolinones are broadly grouped together due to their shared property of:

(A) Inhibiting photosystem II (PSII)
(B) Disrupting cell membrane integrity via lipid peroxidation
(C) Mimicking natural auxin hormones
(D) Inhibiting the acetolactate synthase (ALS) enzyme

2014
9. An emulsifiable concentrate (EC) herbicide formulation must typically be mixed with water before application. What is the primary function of the emulsifying agent in this formulation?
(A) To completely dissolve the active chemical ingredient directly into the carrier water phase
(B) To allow the oil-soluble active ingredient to form stable micro-droplets in water
(C) To chemically prevent the active pesticide ingredients from degrading under ultraviolet light
(D) To significantly increase the overall viscosity of the spray solution to reduce drift

2006
10. The fundamental physiological mode of action for dinitroaniline herbicides (e.g., pendimethalin) is the:
(A) Inhibition of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)
(B) Uncoupling of oxidative phosphorylation in mitochondria
(C) Disruption of microtubule assembly during mitosis
(D) Inhibition of acetyl-CoA carboxylase (ACCase)

2013
11. Which of the following is NOT a recognized physiological mechanism of herbicide selectivity in crops?
(A) Rapid metabolic detoxification of the herbicide molecule
(B) Compartmentalization of the active ingredient into the vacuole
(C) Differential translocation away from the active site
(D) Exudation of the intact herbicide through the stomata

2005
12. Which statement correctly distinguishes cross-resistance from multiple resistance in weed populations?
(A) Cross-resistance involves one mechanism for multiple herbicides, whereas multiple resistance involves several distinct mechanisms.
(B) Cross-resistance involves resistance across multiple chemical classes with distinct modes of action, while multiple resistance is restricted to a single site of action.
(C) Cross-resistance is exclusively driven by metabolic detoxification pathways, while multiple resistance is solely mediated by alterations at the target-site.
(D) Cross-resistance typically develops over a period of several decades of continuous use, whereas multiple resistance emerges rapidly within a single cropping season.

2011
13. An increase in soil organic matter content generally leads to which of the following effects on a soil-applied, non-polar herbicide?
(A) Significantly increased leaching and movement of chemical residues into groundwater
(B) Increased soil adsorption and reduced bioavailability
(C) Decreased adsorption to clay and organic soil colloids under typical field conditions
(D) Accelerated photolytic degradation on the soil surface due to solar radiation

2001
14. Which degradation pathway is most responsible for the breakdown of thiocarbamate herbicides in warm, moist soils?
(A) Abiotic chemical hydrolysis
(B) Microbial breakdown
(C) Surface photodegradation
(D) Rapid thermal volatilization

2021
15. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Flat fan nozzles are generally preferred over hollow cone nozzles for the application of pre-emergence herbicides.
Reason (R): Flat fan nozzles produce a uniform spray pattern with overlapping edges, ensuring even distribution across the soil surface.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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2001

16. In the context of biological weed control, the inundative (or bioherbicide) approach is characterized by:
(A) Releasing a small number of exotic insects to establish a permanent, self-sustaining population
(B) Utilizing herbivorous fish to eradicate emergent aquatic weeds over several years
(C) Applying massive doses of a native pathogen to achieve rapid, localized weed suppression
(D) Employing competitive cover crops to suppress weed emergence during the fallow period

2021

17. Which of the following is NOT a commercially registered mycoherbicide formulation used for weed management?
(A) Collego
(B) Devine
(C) Biopolaris
(D) Glyphosate

2006

18. Identify the INCORRECT statement regarding the principles of Integrated Weed Management (IWM).
(A) IWM seeks to maintain target weed populations well below the economic threshold level rather than aiming for absolute eradication.
(B) IWM systematically incorporates preventive, cultural, mechanical, and chemical control methods in a highly compatible manner.
(C) IWM restricts herbicide use exclusively to severe emergency situations.
(D) IWM strongly emphasizes long-term ecological sustainability and minimizing selection pressure for herbicide resistance.

2014

19. A systemic herbicide applied to a leguminous crop effectively controls the attached parasitic weed Orobanche. The transport of this herbicide from the crop to the parasite primarily occurs through the:
(A) Crop xylem into the parasite xylem
(B) Crop phloem via the established haustorial connections
(C) Volatilization from the crop leaves into the parasite stem
(D) Exudation into the soil and subsequent root uptake by the parasite

2023

20. Water hyacinth (Eichhornia crassipes) is ecologically classified as which type of aquatic weed?
(A) Submerged rooted
(B) Emergent aquatic
(C) Marginal bank
(D) Floating

2007

21. For the management of complex weed flora in transplanted rice, which application schedule is considered correct and highly effective?
(A) Pre-emergence pretilachlor followed by post-emergence bispyribac-sodium
(B) Pre-plant incorporation of 2,4-D followed by sequential post-emergence application of pendimethalin
(C) Pre-emergence application of selective fenoxaprop followed by non-selective pre-plant paraquat
(D) Late post-emergence application of broad-spectrum butchalor at 45 days after crop transplanting

NODIA

2015

22. The frequent use of plastic film mulching in high-value vegetable cultivation primarily suppresses weed growth via which mechanism?
(A) Actively releasing highly concentrated allelopathic chemical exudates directly into the root zone
(B) Significantly increasing local soil salinity well beyond the natural tolerance limit of weed seeds
(C) Physically blocking emergence and light penetration
(D) Rapidly creating a completely sterile subterranean environment that eliminates crucial soil microbial life

2016

23. The widespread adoption of Roundup Ready (glyphosate-tolerant) crops has directly resulted in which significant ecological implication?
(A) Rapid selection of glyphosate-resistant weed biotypes
(B) The complete and permanent eradication of competitive perennial weed species in modern agrosystems
(C) A significant and measurable increase in the direct phytotoxicity of glyphosate to non-target soil insect pests
(D) A severe, long-term degradation in soil structural integrity caused by continuous

chemical accumulation

2018

24. In precision weed management, site-specific herbicide application relies primarily on which technology to differentiate weeds from crops in real-time?

(A) Detailed Geographic Information Systems (GIS) mapping of multi-year historic crop yield data

(B) Advanced time-domain reflectometry (TDR) sensors measuring continuous real-time soil moisture levels

(C) Precision cup-anemometers continuously measuring localized micro-climate wind drift patterns

(D) Machine vision using spectral and morphological analysis

2015

25. Match the economic evaluation concepts in List I with their definitions in List II:

List I: (Economic Evaluation Concept)

P. Cost-Benefit Ratio (CBR)

Q. Partial Budgeting

R. Economic Threshold Level

S. Damage Boundary

List II: (Definition)

1. Compares the financial impact of a specific change against the current practice
2. The weed density where crop yield loss becomes statistically measurable
3. Gross returns divided by total costs
4. The weed density where control costs equal the value of preserved yield

(A) P-1, Q-3, R-2, S-4

(B) P-3, Q-1, R-4, S-2

(C) P-4, Q-2, R-1, S-3

(D) P-3, Q-2, R-4, S-1

2012

26. The production of specialized underground stems for vegetative propagation, such as those found in Cynodon dactylon, defines which biological structure?

(A) Underground tubers

(B) Lateral stolons

(C) Rhizomes

(D) Fleshy corms

2005

27. Identify the correct statement characterizing the hydrochory mechanism of weed seed dispersal.

(A) It relies exclusively on specialized seed adaptations like light pappus or wings to travel long distances across open water surfaces.

(B) It involves the active or passive ingestion of resilient seeds by migratory aquatic fauna for internal transportation.

(C) It is strictly and ecologically limited to highly specialized, submerged aquatic weed species in deep-water environments.

(D) It utilizes seed buoyancy for transport via irrigation water.

2016

28. Which of the following is NOT a characteristic of a legally designated "noxious weed"?

(A) It is defined strictly by its evolutionary origin.

(B) It is formally regulated and monitored by specific state or national quarantine legislation.

(C) It poses a highly severe, immediate threat to overall agricultural production or vulnerable natural ecosystems.

(D) It requires mandatory statutory directives or legal enforcement for its systematic control or eradication.

2018

29. If a tall, broad-leaved weed species rapidly overtop a shorter cereal crop early in the season, the predominant cause of subsequent crop yield reduction is competition for:

(A) Soil moisture

(B) Light

(C) Soil nitrogen

(D) Carbon dioxide

2002

30. A field trial yields 500 kg/ha of weed dry weight in the control plot and 100 kg/ha in the herbicide-treated plot. What is the Weed Control Efficiency (WCE)?

(A) 20%

(B) 80%

(C) 40%

(D) 400%

2025

31. Which of the following is a recognized class of secondary metabolites commonly functioning as allelochemicals?

(A) Phenolic acids

(B) Primary carbohydrates

(C) Structural cellulose

(D) Phospholipids

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2018

32. Identify the INCORRECT statement regarding weed shifts under continuous conservation agriculture (zero tillage).
(A) Annual broadleaf weeds generally show a steady decrease in population density while tough perennial weeds often increase over time.
(B) Wind-dispersed weed seeds tend to heavily accumulate on the undisturbed soil surface, strongly favoring small-seeded annuals.
(C) Deep-rooted perennials are completely eliminated without mechanical tillage.
(D) The continuous, heavy reliance on pre-plant, non-selective chemical herbicides alters the dominant emerging weed flora.

2006

33. A pre-plant incorporated (PPI) application is primarily utilized for highly volatile herbicides to prevent:
(A) Rapid leaching of chemical compounds deep beyond the crop root zone
(B) Immediate and direct absorption of the chemical by the germinating crop seed
(C) Rapid chemical hydrolysis triggered by the presence of surface moisture
(D) Photodegradation and vapor loss

2024

34. In herbicide formulation, a surfactant functions primarily to:
(A) Completely neutralize the highly alkaline or acidic pH of the carrier spray water
(B) Significantly increase the overall surface tension of the individual spray droplet
(C) Decrease droplet surface tension to improve leaf coverage
(D) Securely bind the active herbicide ingredient firmly to complex soil organic matter

2012

35. Consider the following statements regarding herbicide target sites:
I. EPSPS inhibitors block the synthesis of aromatic amino acids.
II. ACCase inhibitors exclusively affect dicotyledonous weed species.
III. Synthetic auxins induce uncontrolled growth and epinasty in broadleaf weeds.
IV. ALS inhibitors block the production of branched-chain amino acids.
Which of the above statements is/are INCORRECT?
(A) I and III
(B) II and III
(C) I and IV
(D) II only

2001

36. The process by which a plant isolates a toxic herbicide molecule inside cellular vacuoles, preventing it from reaching its target site, is termed:
(A) Metabolic degradation
(B) Differential absorption
(C) Extracellular excretion
(D) Compartmentalization

2008

37. Which of the following is NOT a characteristic of target-site mutation resistance?
(A) Broad resistance to entirely different modes of action
(B) A specific structural alteration in the DNA sequence coding directly for the target enzyme
(C) Significantly reduced binding affinity of the active herbicide molecule to the target enzyme
(D) Often genetically inherited as a highly dominant or semi-dominant trait across generations

2009

38. The extensive downward movement of a water-soluble herbicide through a sandy soil profile following heavy rainfall is caused by:
(A) Adsorption
(B) Volatilization
(C) Leaching
(D) Desorption

2007

39. The cleavage of an herbicide molecule facilitated by the addition of water, often mediated by soil pH extremes rather than microbes, is an example of:
(A) Chemical hydrolysis
(B) Microbial oxidation
(C) Photolytic degradation
(D) Conjugation

2011

40. Which specific sprayer nozzle is universally recommended for the broadcast application of contact and systemic herbicides to achieve fine-to-medium uniform droplets?
(A) Flood jet nozzle
(B) Hollow cone nozzle
(C) Solid stream nozzle

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(D) Flat fan nozzle

2014
41. Identify the correct statement regarding classical biological control of weeds.
(A) It involves the continuous, intensive, and annual application of extremely high doses of native fungal pathogens.
(B) It introduces exotic enemies to permanently suppress invasive weeds.
(C) It actively aims for the complete and rapid eradication of the target weed species within a single cropping season.
(D) It primarily utilizes widely available generalist mammalian herbivores like grazing cattle or domestic sheep.

2019
42. The commercial bioherbicide "Devine" is formulated from which type of biological agent, and what is its target weed?
(A) A highly specific pathogenic soil bacterium targeting parasitic Striga species
(B) Host-specific phytophagous insect targeting invasive aquatic water hyacinth
(C) A fungus targeting stranglervine
(D) A highly contagious viral pathogen targeting widespread Parthenium hysterophorus

2011
43. Which of the following is NOT considered a cultural method of weed management?
(A) Adjusting crop row spacing and plant density
(B) Utilizing competitive, locally adapted crop cultivars
(C) Altering the timing of fertilizer application to favor the crop
(D) Employing a moldboard plow for deep inversion tillage

2015
44. The parasitic weed Striga asiatica predominantly infests which group of host crops?
(A) Cereals like sorghum, maize, and pearl millet
(B) Solanaceous agricultural crops and vegetables like tomato and potato
(C) Legumes like chickpea and lentil
(D) Plantation crops like tea and coffee

2018
45. What is the correct sequence of aquatic weed habitat colonization, progressing from the deepest water to the shoreline?
(A) Floating → Submerged → Emergent → Marginal
(B) Submerged → Floating → Emergent → Marginal
(C) Submerged → Emergent → Floating → Marginal
(D) Marginal → Emergent → Floating → Submerged

2021
46. The application of 2,4-D in wheat fields is timed accurately between 30 to 35 days after sowing. Applying it too early typically results in what effect on the crop?
(A) Significantly enhanced crop vegetative tillering and overall dry biomass
(B) Malformation of roots and spikes
(C) Accelerated and premature senescence of the lower structural leaves
(D) Greatly increased susceptibility of the plants to destructive fungal rusts

2011
47. In established perennial orchard systems, an effective integrated weed management strategy often relies on:
(A) Maintaining a sod cover or utilizing directed post-emergence herbicide sprays
(B) Frequent deep tillage within the tree root zone
(C) Broadcast application of non-selective systemic herbicides over the tree canopy
(D) Pre-plant incorporation of volatile herbicides every season

2006
48. In the development of Genetically Modified (GM) herbicide-tolerant crops, the process of transferring the engineered resistance trait from a transformed line into elite commercial cultivars is called:
(A) Mutagenesis
(B) Somaclonal variation
(C) Trait introgression
(D) Polyploidization

NODIA

2006
49. Identify the INCORRECT statement concerning machine vision for precision weed management.
(A) It dynamically distinguishes target weeds from cultivated crops based on leaf shape, texture, and spectral reflectance parameter.
(B) It systematically allows for precision targeted micro-dosing of herbicides directly onto individual weed foliage.
(C) It significantly and predictably reduces the total volumetric quantity of chemical herbicide applied per hectare.

(D) It works well in completely obscured weed-crop canopies.

2004

50. In partial budgeting for weed control, if the additional revenue generated by a new herbicide treatment is less than its additional cost, the Cost-Benefit Ratio (incremental) will be:
(A) Exactly 1.0
(B) Greater than 1.0
(C) Less than 1.0
(D) Zero

2021

51. Which of the following factors does NOT negatively influence the long-term viability of weed seeds buried deep in the soil profile?
(A) Severe depletion of seed metabolic food reserves over long periods of time
(B) Absolute lack of light
(C) Pathogenic fungal infection or direct soil microbial decay of seed tissues
(D) Active predation by various deep-burrowing soil insects and macroscopic organisms

2010

52. When grazing livestock consume mesquite pods and later excrete intact seeds in a distant pasture, the resulting geographic spread is a classic effect of:
(A) Anemochory
(B) Anthropochory
(C) Hydrochory
(D) Endozoochory

2009

53. An agricultural inspector detains a shipment of wheat seed because it contains seeds of an aggressive alien weed species currently not present in the country. This weed is legally classified as a:
(A) Quarantine weed
(B) Facultative weed
(C) Obligate weed
(D) Native noxious weed

2015

54. Competition for light between crops and weeds becomes most critical during which stage of crop development?
(A) Initial seed germination and emergence phase
(B) Late physiological maturity and grain filling stage
(C) Early vegetative establishment
(D) Post-harvest stubble and field fallow phase

2018

55. Consider the following statements regarding Economic Threshold Level (ETL) and Damage Boundary:
I. ETL is always mathematically lower than the Damage Boundary.
II. ETL represents the weed density where the cost of control equals the value of crop yield saved.
III. Below the Damage Boundary, weed presence causes no statistically measurable yield loss.
IV. Implementing control measures at weed densities below the ETL is economically justifiable.
V. The Economic Threshold Level varies with market prices and control costs, while the Damage Boundary is a biological threshold.
Which of the above statements are correct?
(A) I, II, III and IV
(B) II, III and V
(C) I, III and V
(D) II, IV and V

2011

56. Allelochemicals that restrict the growth of the producing plant's own seedlings (auto-toxicity) exhibit which type of effect?
(A) Stimulatory
(B) Synergistic
(C) Commensal
(D) Inhibitory

2016

57. Identify the correct dynamic regarding flora succession under continuous application of a single herbicide mode of action.
(A) The local weed flora rapidly and completely shifts towards species highly susceptible to that herbicide.
(B) The flora shifts toward species naturally resistant to it.
(C) Overall species and genetic weed diversity within the localized ecosystem dramatically increases.
(D) The subterranean soil seed bank reserves rapidly and permanently deplete entirely over time.

2017

58. Which of the following is NOT a characteristic of a contact herbicide?
(A) It causes localized, acute cellular injury only to the specific plant tissues it physically touches.
(B) It strictly requires uniform and excellent

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spray coverage across the leaf surface for effective control.
(C) It translocates extensively to kill deep roots.
(D) It exhibits extremely rapid visual symptom development on highly susceptible target weed foliage.

2012
59. Applying a high concentration of an emulsifiable concentrate (EC) formulation during periods of extreme high temperature and low humidity may cause:
(A) Highly enhanced and rapid systemic vascular translocation of chemicals
(B) Rapid physical freezing and crystallization of the active pesticide ingredient
(C) Immediate and aggressive microbial enzymatic degradation within the soil matrix
(D) Phytotoxic crop leaf burn

2013
60. A farmer applies a sulfonylurea herbicide and notices that susceptible weeds halt growth immediately, showing purpling and chlorosis of the meristematic tissues a week later. This confirms the herbicide's action as an:
(A) ALS inhibitor
(B) ACCase inhibitor
(C) EPSPS inhibitor
(D) HPPD inhibitor

2009
61. Differential absorption, a mechanism of herbicide selectivity, is predominantly influenced by which plant morphological feature?
(A) The cellular anatomy and physical structure of the root endodermis barrier
(B) Epicuticular wax layer thickness and composition
(C) The total number and distribution of functional chloroplasts per mesophyll cell
(D) The specific genomic and amino acid sequence of the primary target enzyme system

2006
62. A weed population develops resistance to a triazine herbicide. Genetic testing reveals a single amino acid substitution (Serine to Glycine) at position 264 in the D1 protein. This is a definitive case of:
(A) Enhanced metabolism resistance
(B) Target-site mutation resistance
(C) Compartmentalization resistance
(D) Reduced translocation resistance

2004
63. The process by which an herbicide molecule detaches from a soil particle surface and re-enters the soil solution is known as:
(A) Desorption
(B) Absorption
(C) Adsorption
(D) Volatilization

2007
64. Identify the INCORRECT statement regarding the photodegradation of herbicides.
(A) It is the rapid chemical breakdown and degradation of herbicides triggered by ultraviolet (UV) light energy.
(B) It primarily affects chemical herbicide residues remaining directly on the exposed soil surface or plant foliage.
(C) It increases when herbicides are incorporated into the soil.
(D) Specific herbicides like trifluralin and other volatile chemicals are highly susceptible to this process.

2011
65. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Regular calibration of a knapsack sprayer is essential prior to applying selective post-emergence herbicides.
Reason (R): Calibration ensures the delivery of the exact recommended volume of herbicide mixture per unit area, preventing both under-dosing and crop phytotoxicity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015
66. In classical biological control, introducing an insect agent without conducting rigorous host-specificity testing may cause:
(A) Complete and rapid biological eradication of the targeted invasive weed populations
(B) Highly enhanced or prolonged weed seed dormancy cycles within the local seedbank
(C) Feeding on non-target crops or native flora
(D) Significantly increased chemical efficacy of traditional soil-applied herbicides

NODIA

2005

67. The bioherbicide formulation 'Collego' primarily utilizes an endemic fungal pathogen (Colletotrichum gloeosporioides f. sp. aeschynomene) to control which specific weed in rice and soybean?
(A) Echinochloa crus-galli commonly known as Barnyard grass
(B) Aeschynomene virginica (Northern jointvetch)
(C) Cyperus rotundus commonly known as Purple nutsedge
(D) Monochoria vaginalis commonly found in wetland ecosystems

2024

68. The practice of cleaning combine harvesters before moving them from an infested field to a clean field falls under which category of weed management?
(A) Cultural control
(B) Direct mechanical control
(C) Eradication
(D) Preventive control

2024

69. Which of the following characteristics does NOT apply to the parasitic weed Cuscuta (Dodder)?
(A) It attaches to the host roots underground.
(B) It is a highly specialized holoparasitic plant that is completely dependent on its host for survival.
(C) It entirely lacks developed true leaves and any form of functional photosynthetic chlorophyll.
(D) It utilizes specialized parasitic haustoria structures to deeply penetrate the tissues of the host stem.

2023

70. Identify the correct ecological classification for Hydrilla verticillata based on its growth habit.
(A) Free-floating unattached aquatic weed species
(B) Emergent shoreline aquatic weed species
(C) Submerged rooted weed
(D) Marginal deep-rooted phreatophyte species

2004

71. The application of pendimethalin as a pre-emergence herbicide is widely recommended for weed control in major pulse crops. This recommendation relies on the inference that pulse crops possess:
(A) Deep taproots avoiding the treated zone (positional selectivity)
(B) Highly specific target-site insensitivity or genetic resistance to pendimethalin molecules
(C) Rapid metabolic detoxification enzymes that actively conjugate pendimethalin inside cells
(D) Complete evolutionary resistance to all chemical classes of dinitroaniline herbicides

2023

72. In mature tea plantations, the most challenging problematic weeds to manage are typically:
(A) Highly competitive and prolific short-lived annual grasses
(B) Extremely small-seeded annual broadleaf weed species
(C) Non-parasitic epiphytic orchids growing on old branches
(D) Perennial grasses like Imperata cylindrica

2019

73. The Liberty Link genetically modified trait confers crop tolerance to which specific broad-spectrum herbicide?
(A) Broad-spectrum glyphosate
(B) Glufosinate
(C) Synthetic auxin dicamba
(D) Selective herbicide 2,4-D

2007

74. Utilizing agricultural drones for herbicide spraying in undulating terrain provides the distinct advantage of:
(A) Significantly increasing the total volumetric rate of herbicide spray applied per hectare
(B) Completely and permanently replacing all traditional pre-emergence soil-applied applications
(C) Spraying in areas inaccessible to heavy ground machinery
(D) Absolutely and completely eliminating any possibility of post-application spray drift

2012

75. Match the parameters in List I with their analytical descriptions in List II:
List I: (Parameter)
P. Gross Return
Q. Variable Cost
R. Fixed Cost
S. Net Return
List II: (Analytical Description)
1. The total market value of the harvested crop yield
2. The cost of the herbicide and labor for application

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3. Land rent and machinery depreciation
4. Gross Return minus Total Cost

(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-4, Q-1, R-2, S-3

2003

76. To overcome morphological seed dormancy caused by an immature embryo, which physiological process or treatment is generally required?
(A) Stratification
(B) Mechanical scarification
(C) Environmental hypoxia induction
(D) Prolonged exposure to complete darkness

2016

77. Anthropochory, a highly efficient means of weed seed dissemination, refers strictly to seed transport mediated by:
(A) Flowing irrigation or natural river water currents
(B) Human activities
(C) Migratory birds feeding on or carrying seeds externally
(D) Prevailing local atmospheric wind currents and drafts

2005

78. Ontogeny-based classification categorizes weeds strictly according to their:
(A) Specific ecological habitat and growing preference
(B) Life cycle duration
(C) Internal photosynthetic pathway variations (C_3 versus C_4 plants)
(D) Embryonic leaf structure differences (monocots versus dicots)

2012

79. Identify the INCORRECT statement regarding crop-weed competition for moisture.
(A) High soil moisture guarantees that light competition will not occur.
(B) Weeds generally have a higher transpiration coefficient than cultivated crops.
(C) Competition for moisture is most severe in rainfed or dryland agricultural systems.
(D) Weeds with deep taproots typically outcompete shallow-rooted crops during drought.

2022

80. An increase in the market price of an agricultural commodity generally causes the Economic Threshold Level (ETL) of weeds to:
(A) Rapidly increase, thereby tolerating much higher field weed densities
(B) Remain completely and statically unchanged regardless of market shifts
(C) Decrease, justifying earlier control
(D) Become exactly equal to the statistically determined Damage Boundary

2018

81. Which of the following is NOT a recognized natural release mechanism for allelochemicals from plants?
(A) Continuous leaching from above-ground foliage triggered by rainfall events
(B) Direct gaseous volatilization from the surfaces of living leaves
(C) Gradual biological decomposition of remaining plant residues in the soil profile
(D) Absorption of neighboring root exudates

2001

82. Transitioning from conventional moldboard plowing to a strict shallow cultivation regime will likely shift the weed flora toward:
(A) Deeply buried, long-dormant seed-producing weed annuals
(B) Exclusively and strictly obligate parasitic host-specific weeds
(C) Small-seeded annuals and shallow perennials
(D) Large-seeded competitive dicot weeds requiring deep physical soil burial

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2009

83. Glyphosate is classified as a systemic herbicide. This classification dictates that the chemical must:
(A) Rapidly burn and destroy exposed plant foliage upon immediate direct physical contact
(B) Translocate through the vascular system to meristems
(C) Remain chemically active and stable solely within the surrounding soil solution phase
(D) Completely inhibit seed germination processes well before any visible seedling emergence

2015

84. Identify the correct physical property of a Water Dispersible Granule (WDG) formulation.
(A) It is a dry formulation that completely and instantly dissolves into a clear, true molecular solution.
(B) It consists of concentrated liquid active ingredients encapsulated inside tiny,

microscopic plastic beads.
(C) It is a highly specialized, oil-based emulsifiable liquid suspended uniformly in a thick, dense clay paste.
(D) It is dry granules that break apart and suspend in water.

2005

85. Consider the following statements regarding Photosystem II (PSII) inhibitor herbicides:
I. They bind to the D1 protein in the chloroplast, blocking electron transport.
II. Their primary symptom is rapid root necrosis prior to any foliar chlorosis.
III. Triazines and ureas belong to this mode-of-action group.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2019

86. The cause of poor weed control following the application of a systemic post-emergence herbicide during a severe drought is primarily:
(A) Excessive downward leaching of the highly water-soluble herbicide far past the active root zone
(B) Extremely enhanced and rapid gaseous volatilization of the active chemical ingredient from leaves
(C) Stress-induced reduction in absorption and translocation
(D) Rapid and complete abiotic chemical hydrolysis occurring instantly on the dry leaf cuticle surface

2009

87. Multiple herbicide resistance in a weed population is definitively confirmed when the population survives field rates of:
(A) Different chemical families with distinct modes of action
(B) Two or more distinct herbicides chemically affecting the exact same physiological target enzyme
(C) A single specific herbicide chemical compound applied repeatedly at progressively higher concentrations
(D) Multiple herbicides utilizing the exact same active ingredient but using different formulation types

2009

88. A farmer applies a highly volatile herbicide (e.g., EPTC) on a hot day without immediate incorporation. The primary fate of the chemical will be:
(A) Irreversible adsorption to clay minerals
(B) Deep leaching into the groundwater
(C) Rapid oxidation by soil microbes
(D) Volatilization into the atmosphere

2008

89. In the biochemical pathway of in-plant herbicide metabolism, the process of attaching a glucose molecule to a detoxified herbicide fragment is known as:
(A) Enzymatic oxidation
(B) Conjugation
(C) Chemical reduction
(D) Acid/base hydrolysis

2005

90. Which of the following operational adjustments does NOT mitigate or reduce herbicide spray drift?
(A) Lowering the boom height closer to the target
(B) Utilizing nozzles that produce a larger droplet size
(C) Increasing the application pressure significantly
(D) Spraying during early morning when wind speeds are minimal

2017

91. Identify the INCORRECT statement concerning the use of phytopathogens in biological weed control.
(A) They are often formulated as mycoherbicides for inundative application.
(B) They generally require specific environmental conditions (e.g., high humidity) to cause infection.
(C) They are highly virulent and host-specific.
(D) They typically possess a broad host range, attacking multiple crops alongside weeds.

2016

92. The efficacy of a foliar-applied mycoherbicide is critically dependent on environmental conditions. A lack of free moisture or dew post-application will directly cause:
(A) Spore desiccation and failure to infect
(B) Highly enhanced and rapid fungal spore penetration directly through closed stomatal openings
(C) Rapid and continuous gaseous volatilization

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of the applied living fungal spores into the air
(D) Immediate and complete chemical conversion of the biological formulation into a synthetic product

2022
93. Utilizing a rotary hoe to uproot small weed seedlings precisely during the "white thread" stage of weed germination is an application of:
(A) Preemptive preventive control
(B) Mechanical control
(C) Cultural control
(D) Biological control

2021
94. The obligate root parasitic weed Orobanche spp. is most problematic in the cultivation of which commercially important crop?
(A) Flooded paddy rice
(B) Mustard
(C) Commercial sugarcane
(D) Long-staple cotton

2011
95. Consider the following statements characterizing emergent aquatic weeds:
I. They are rooted in bottom mud with stems and leaves extending above the water surface.
II. Typha (cattail) and Phragmites are classic examples.
III. They draw all required nutrients directly from the ambient water, bypassing root uptake.
IV. They are generally confined to shallow marginal areas of water bodies.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) II and IV
(C) I, II and IV
(D) III only

2007
96. The critical timing for post-emergence herbicide application is physiologically dictated by the:
(A) The specific calendar date of primary or secondary tillage operations
(B) The absolute chronological age profile of the subterranean soil seedbank
(C) Weed growth stage and crop tolerance window
(D) The physiological onset of seed maturity within the dominant field weed species

2014
97. Identify the correct integrated weed management strategy commonly employed in short-duration vegetable crops.
(A) Continuous application of non-selective herbicides throughout the vegetative stage
(B) Establishing a thick perennial cover crop alongside the vegetables
(C) Delaying all control measures until after the crop begins to set fruit
(D) Combining a stale seedbed technique with early mechanical inter-row cultivation

2023
98. The transfer of engineered herbicide-tolerance genes from a GM crop to wild, sexually compatible weed relatives via pollen transfer is ecologically termed:
(A) Intraspecific competition
(B) Somatic hybridization
(C) Gene flow (introgression)
(D) Horizontal gene transfer via Agrobacterium

2010
99. Which practice negates the benefits of site-specific weed management?
(A) Utilizing advanced GPS-guided real-time micro-sprayers to target specific patches
(B) Uniform broadcast application across the field
(C) High-resolution mapping of weed patches using multi-spectral reflectance drones
(D) Seamlessly interfacing sensor data with automated variable rate technology equipment

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2016
100. Assessing the financial viability of a manual weeding operation versus a chemical herbicide program primarily requires calculating the:
(A) Gross Returns of the unweeded control
(B) Total amortized cost of the land
(C) Total volumetric amount of irrigation water utilized during the crop life cycle
(D) Cost-Benefit Ratio and Net Returns of each treatment

2003
101. Innate (primary) dormancy in seeds at the time of dispersal is caused by:
(A) Genetic or physiological traits of the seed
(B) Deep physical burial and compaction within the subterranean soil profile
(C) Continuous environmental exposure to freezing temperatures post-shattering
(D) Severe localized depletion of essential soil

oxygen and aeration levels

2023

102. Anemochory is most effective for weed seeds that possess which specific anatomical adaptation?
(A) Highly attractive, fleshy, and sweet external pericarps
(B) Light, corky, and air-filled cellular buoyancy tissues
(C) Pappus, hairs, or wings
(D) Highly adhesive hooked spines or sharp barbed awn structures

2016

103. Under international quarantine regulations, a "noxious weed" is distinguished primarily because it:
(A) Is legally restricted due to its potential harm
(B) Fixes biological atmospheric nitrogen in an extremely inefficient ecological manner
(C) Possesses visually attractive and highly vibrant ornamental flower structures
(D) Completes its entire physiological and reproductive life cycle within three weeks

2002

104. Crop-weed competition for nutrients is characterized by:
(A) Crops consistently and successfully out-competing invasive weeds for vital soil phosphorus reserves due to a larger initial root system mass
(B) Weeds actively releasing large quantities of fixed nitrogen compounds to satisfy nearby crop plant nutritional requirements
(C) Complete and systematic physical exclusion of weed root system growth and development when grown in highly fertile soil types
(D) Weeds extracting nutrients faster and in larger quantities

2023

105. What is the correct logical sequence of steps for calculating the Economic Threshold Level (ETL) of a weed?
I. Determine the proportional yield loss per weed per unit area.
II. Calculate the total cost of the weed control measure.
III. Estimate the expected crop yield and its market price (value).
IV. Solve for the weed density where control cost equals the monetary value of lost yield.
(A) II, III, I, IV
(B) III, II, I, IV
(C) I, II, III, IV
(D) IV, III, II, I

NODIA

2009

106. Identify the INCORRECT statement regarding allelochemical effects.
(A) Allelochemicals generally inhibit seed germination or root elongation in susceptible species.
(B) Some allelochemicals may exhibit stimulatory effects at extremely low concentrations.
(C) Their inhibitory concentration remains constant across all soil types.
(D) They can mediate amensalistic relationships between weed and crop species.

2017

107. The transition to a conservation agriculture system retaining high surface crop residues causes pre-emergence herbicides to:
(A) Act significantly faster in the profile due to localized increases in soil surface temperature
(B) Volatilize instantly upon leaving the spray nozzle before hitting the residue canopy
(C) Penetrate deeper into the groundwater profile via soil macropores and preferential flow paths
(D) Be intercepted by the residue, requiring higher application rates or spray volumes to reach the soil

2006

108. A pre-emergence (PRE) herbicide application aims to control weeds at which specific physiological stage?
(A) During weed germination and subterranean emergence
(B) Immediately following the expansion of the first true leaves
(C) At the physiological onset of reproductive flowering
(D) Before the dry weed seed imbibes any soil water

2015

109. Granular formulations of herbicides are generally preferred for:
(A) Foliar broadcast application to large, highly competitive mature broadleaf weeds
(B) Application in standing water systems or soil incorporation without liquid drift
(C) Precision micro-dosing of individual weed seedlings using manual backpack sprayers
(D) Direct tank-mixing with foliar fertilizers for rapid canopy absorption and uptake

2002
110. Which herbicide group does NOT target the Acetyl-CoA carboxylase (ACCase) enzyme?
(A) Aryloxyphenoxypropionates (FOPs)
(B) Imidazolinones (IMIs)
(C) Cyclohexanediones (DIMs)
(D) Phenylpyrazolins (DENs)

2013
111. Maize naturally tolerates the herbicide atrazine due to a high concentration of the enzyme glutathione S-transferase (GST). This inference describes which mechanism of selectivity?
(A) Biochemical metabolic selectivity
(B) Physical positional selectivity
(C) Structural morphological selectivity
(D) Ontogenic developmental selectivity

2019
112. Enhanced metabolism resistance in weeds is defined as:
(A) A structural mutation in the target enzyme preventing active herbicide binding
(B) The rapid active excretion of intact herbicide molecules back into the soil matrix
(C) Accelerated enzymatic breakdown into non-toxic metabolites before reaching the target site
(D) The massive overproduction of target enzymes to effectively out-compete the molecule

2025
113. Identify the correct definition of an herbicide's "half-life" in soil.
(A) The time required for half of the applied chemical to leach completely out of the root zone
(B) The total duration that the applied herbicide remains highly toxic to all surrounding plant life
(C) The time required for exactly half of the soil-applied herbicide to be absorbed by the crop
(D) The time required for soil herbicide concentration to degrade to 50% of its initial value

2021
114. The enzymatic addition of oxygen to an herbicide molecule within a plant, often mediated by Cytochrome P450 monooxygenases, is an example of:
(A) Phase II conjugation
(B) Phase III compartmentalization
(C) Phase I oxidation
(D) Chemical hydrolysis

2009
115. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Flood jet nozzles are commonly used for applying post-emergence systemic herbicides where fine coverage is critical.
Reason (R): Flood jet nozzles operate at low pressure and produce very coarse droplets, which drastically reduces spray drift.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008
116. The introduction of the Eriophyid mite (Aceria chondrillae) successfully controlled rush skeletonweed (Chondrilla juncea). This represents the use of which bio-control agent class?
(A) Fungal plant pathogens
(B) Nematodes
(C) Coleopteran insects
(D) Phytophagous mites

2024
117. The production of mycoherbicides at a commercial scale predominantly involves mass-culturing the fungal agent in liquid fermentation tanks to produce abundant:
(A) Mycelial fragments or resistant fungal spores
(B) Motile zoospores requiring saturated soils or standing water
(C) Complex multicellular structures like macroscopic mushrooms
(D) Intact specialized vegetative haustorial structures

2025
118. Which statement correctly defines chemical weed control within an IWM framework?
(A) It acts as the single, completely independent method for permanently eradicating all weed species from the area.
(B) It entirely replaces all manual, mechanical, and cultural methods due to its superior short-term cost-efficiency.
(C) It is a tactical tool integrated with other methods to manage populations and mitigate resistance.
(D) It focuses exclusively on highly intensive, non-selective broadcast applications across

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the entire field canopy.

2017

119. Identify the INCORRECT statement concerning the parasitic weed Loranthus.
(A) It parasitizes the root systems of annual cereal crops.
(B) It is a hemi-parasite, possessing green leaves and performing its own photosynthesis.
(C) It primarily infests the branches of woody perennial host trees.
(D) Its seeds are widely disseminated by birds (zoochory).

2023

120. A massive proliferation of floating aquatic weeds like Salvinia molesta causes which severe ecological effect on the water body?
(A) A rapid, highly pronounced increase in deep-water light penetration throughout the water column
(B) Continuous hyper-oxygenation of the benthic zone driven by increased atmospheric gas exchange
(C) Complete, uniform stabilization of water temperatures across both shallow and deep layers
(D) Depressed dissolved oxygen and blocked sunlight, killing submerged flora and fauna

2009

121. In major oilseed crops like groundnut or soybean, the Critical Period of Weed Control (CPWC) generally falls within:
(A) 60 to 90 days after sowing
(B) 15 to 45 days after sowing
(C) 0 to 5 days after sowing
(D) The final pod-filling stage exclusively

2010

122. In high-value vegetable systems, the absolute zero-tolerance for weed competition early in the season is largely due to:
(A) The aggressive, rapid vertical height development of vegetable seedlings
(B) The highly potent, rapid allelopathic root exudate dominance of vegetables
(C) Their slow early growth and wide row spacing, leaving unshaded soil
(D) The absolute physical inability to employ manual labor or hand weeding

2019

123. Which of the following crop traits is NOT associated with Roundup Ready (glyphosate-tolerant) transgenic technology?
(A) Resistance is conferred by the insertion of the CP4 EPSPS gene.
(B) The crop survives post-emergence applications of glyphosate.
(C) The crop synthesizes aromatic amino acids despite the presence of the herbicide.
(D) The crop metabolizes glyphosate into AMPA to prevent toxicity.

2021

124. Identify the correct application of drone-based weed mapping in agriculture.
(A) Creating spatial maps of weed patches for variable rate herbicide application
(B) Completely replacing all heavy ground-based mechanical tillage machinery systems
(C) Directly altering the internal genetic composition of weed seeds in the topsoil
(D) Efficiently irradiating emerging weed seedlings using high-frequency microwaves

2009

125. Match the weed control evaluation parameters in List I with their respective mathematical formulas in List II.

List I: Weed control evaluation parameters
P. Weed Control Efficiency (WCE)
Q. Weed Index (WI)
R. Herbicide Efficiency Index (HEI)
S. Weed Control Index (WCI) based on density

List II: Mathematical formulas
1. $\left[\frac{\text{Yield weed free} - \text{Yield treated}}{\text{Yield weed free}}\right] \times 100$
2. $\left[\frac{\text{Weed dry weight in control} - \text{Weed dry weight treated}}{\text{Weed dry weight in control}}\right] \times 100$
3. Evaluates both weed-killing efficacy and crop phytotoxicity
4. $\left[\frac{\text{Weed density control} - \text{Weed density treated}}{\text{Weed density control}}\right] \times 100$

(A) P-1, Q-2, R-4, S-3
(B) P-2, Q-1, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-4, R-2, S-1

2023

126. From the robust vegetative propagation of Cyperus rotundus, one can infer that mechanical tillage using a disc harrow during moist conditions will likely:
(A) Completely eradicate the weed population by severing roots
(B) Fragment tuber chains, spreading and propagating the weed
(C) Induce deep, fatal secondary physiological dormancy in tubers

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(D) Cause rapid, complete physical desiccation of active tubers

2017

127. The dispersal of Taraxacum officinale (dandelion) seeds over vast distances is facilitated by a pappus. This dispersal mechanism is defined as:
(A) Anemochory
(B) Hydrochory
(C) Anthropochory
(D) Zoochory

2011

128. According to cotyledon-based classification, weeds belonging to the Poaceae and Cyperaceae families are defined as:
(A) Dicotyledonous weeds (Broad-leaved)
(B) Pteridophytes (Ferns)
(C) Monocotyledonous weeds (Narrow-leaved)
(D) Gymnosperms

2022

129. Crop-weed competition is often termed "asymmetrical" because:
(A) Weeds generally require significantly less water and soil nutrients than crops.
(B) Crops always maintain a genetically determined, absolute vertical height advantage.
(C) Root-zone competition always occurs completely independent of shoot-canopy competition.
(D) The early-emerging plant captures resources, gaining a major advantage.

2012

130. If the calculated Economic Threshold Level (ETL) for wild oats in wheat is 5 plants per square meter, a farmer scouting a field and finding 12 plants per square meter should:
(A) Wait patiently until the weed density drops below five to apply any chemical
(B) Completely abandon the crop field as major economic loss is now inevitable
(C) Implement control measures, as density exceeds the threshold
(D) Apply exactly half of the recommended label rate of the herbicide chemical

2003

131. Which of the following is NOT a mechanism by which soil conditions alter the efficacy of root-exuded allelochemicals?
(A) Adsorption of the allelochemical to clay organic matter
(B) Immediate conversion of the allelochemical into a synthetic herbicide
(C) Rapid degradation of the compound by soil microorganisms
(D) Leaching of the compound out of the active root zone by heavy rainfall

2006

132. Identify the correct impact of instituting a diverse crop rotation system on weed flora dynamics.
(A) It causes a rapid, irreversible increase in the overall abundance of perennial weed species.
(B) It selects almost exclusively for weed species possessing complex secondary dormancy mechanisms.
(C) It renders all soil-applied, pre-emergence residual herbicides completely ineffective in the field.
(D) It disrupts the life cycle of weeds adapted to mono-cropping, reducing their dominance.

2002

133. A post-emergence (POST) herbicide application implies that the herbicide is applied:
(A) After both the crop and weeds have emerged
(B) Directly before the crop is planted in the field
(C) Long before the dry weed seeds imbibe soil moisture
(D) Directly to the bare soil surface before crop emergence

2017

134. In agricultural spray mixtures, surfactants (surface-active agents) are vital because they:
(A) Significantly increase the rate of chemical herbicide photolysis in the field
(B) Physically sever or dissolve delicate weed roots immediately upon direct contact
(C) Reduce water surface tension, helping droplets spread on waxy leaves
(D) Completely prevent the dissolved active ingredient from entering the plant stoma

2017

135. Consider the following statements regarding EPSPS inhibitor herbicides:
I. Glyphosate is the sole commercially significant herbicide in this group.
II. They block the shikic acid pathway, halting the synthesis of phenylalanine, tyrosine, and tryptophan.
III. They are highly selective and safe for non-GM conventional broadleaf crops.
IV. They are strictly contact herbicides with zero phloem mobility.

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V. They are non-selective, systemic herbicides applied post-emergence.

Which of the above statements are correct?

(A) I, II and V
(B) I, II and IV
(C) II, III and V
(D) I, III and IV

2025

136. The selectivity of 2,4-D in controlling broadleaf weeds in wheat is partially due to morphological differences, specifically that:

(A) Wheat roots exude highly active protective enzymes that rapidly degrade the chemical herbicide in the rhizosphere.
(B) Broadleaf weeds completely lack a functional vascular cambium system, preventing herbicide systemic movement.
(C) Wheat possesses highly specialized glandular trichomes on leaf surfaces that actively sequester the toxic herbicide.
(D) Wheat has narrow, upright, waxy leaves that repel droplets, while broadleaves intercept them.

2021

137. A weed population has developed target-site resistance to ALS inhibitors. The most appropriate immediate management strategy is to:

(A) Substantially increase the overall application rate of the ALS inhibitor chemical by fifty percent
(B) Rotate to an alternative herbicide with a completely different mode of action
(C) Apply the identical ALS inhibitor chemical at a much earlier physiological growth stage of the weed
(D) Switch to a completely different physical formulation of the exact same chemical active ingredient

2016

138. The physical or chemical binding of an herbicide molecule to the surface of a soil colloid (clay or organic matter) is defined as:

(A) Volatilization
(B) Leaching
(C) Adsorption
(D) Absorption

2016

139. Identify the INCORRECT statement regarding the microbial degradation of herbicides in soil.

(A) It is the primary pathway of breakdown for the majority of soil-applied herbicides.
(B) It is highly dependent on favorable soil moisture, warm temperatures, and adequate aeration.
(C) Repeated application of certain herbicides (e.g., thiocarbamates) can lead to accelerated microbial degradation.
(D) It occurs most rapidly in completely sterile, highly acidic, and desiccated soils.

2016

140. Which specific type of sprayer is most universally employed for broad-acre herbicide application in modern mechanized cereal farming?

(A) Tractor-mounted boom sprayer
(B) Hand-compression knapsack sprayer
(C) Electrostatic ultra-low volume (ULV) hand-held sprayer
(D) High-pressure orchard air-blast sprayer

2024

141. Which of the following is NOT a typical limitation of classical biological weed control?

(A) The bio-control agent may take several years to establish and meaningfully suppress the weed population.
(B) It is highly effective for rapidly eradicating weeds in intensive, short-duration vegetable cropping systems.
(C) Finding a highly host-specific agent that does not threaten related economic crops is difficult and expensive.
(D) The control achieved is often incomplete and fluctuates with environmental conditions.

2018

142. Mycoherbicides generally rely on endemic fungal plant pathogens. From this, one can infer that their field efficacy is frequently limited by:

(A) The active presence of highly resistant herbivorous insect vectors in fields
(B) A requirement for prolonged leaf wetness to allow spore germination
(C) Rapid chemical photodegradation of the active ingredient by sunlight exposure
(D) Highly severe, extreme chemical toxicity to mammalian operators and handlers

NODIA

2007

143. Implementing an Integrated Weed Management (IWM) system incorporating crop rotation, stale seedbed, and targeted chemical control will likely cause:

(A) Delayed evolution of herbicide resistance and long-term weed suppression

(B) Complete, absolute depletion of the entire soil seedbank profile within one cropping year
(C) A rapid, highly pronounced surge in the emergence of multiple-resistant weed biotypes
(D) A massive, unsustainable increase in total crop production costs with zero yield benefits

2025
144. The specialized organ through which a parasitic weed penetrates host tissues to extract water, minerals, and complex nutrients is the:
(A) Appressorium
(B) Rhizomorph
(C) Haustorium
(D) Mycorrhiza

2016
145. Consider the following statements concerning the management of problematic perennial weeds in non-cropped areas:
I. Intensive, continuous deep tillage is the most effective approach for deep-rooted perennials in permanent industrial sites.
II. Translocated, non-selective herbicides like glyphosate or imazapyr are highly effective because they move into the underground storage organs.
III. Slashing or mowing alone provides excellent long-term eradication of perennial root systems.
Which of the above statements is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) II only

2023
146. A farmer needs to apply a wettable powder (WP) herbicide containing 50% active ingredient (a.i.) at a recommended rate of 1.0 kg a.i. per hectare. How much formulated commercial product is required for one hectare?
(A) 0.5 kg
(B) 1.0 kg
(C) 2.0 kg
(D) 5.0 kg

2019
147. Identify the correct practice for managing weed flora on the floor of a mature fruit orchard.
(A) Conducting frequent, deep moldboard plowing operations extremely close to the main tree trunks
(B) Maintaining cover crops in inter-rows while treating under-canopy zones with directed herbicides
(C) Placing absolute, total reliance on soil-applied pre-emergence herbicides sprayed every single month
(D) Allowing completely unregulated, aggressive growth of deep-rooted perennial weed vines under trees

2023
148. The transgenic trait in Liberty Link crops utilizes the pat or bar gene. What is the source organism from which these genes were originally isolated?
(A) A viral mosaic pathogen
(B) A highly competitive weed species (Amaranthus palmeri)
(C) An aquatic alga
(D) Soil bacteria (Streptomyces spp.)

2015
149. Which of the following is NOT a technical component of a drone-based precision herbicide application system?
(A) Sub-soiling tines for immediate deep incorporation of the chemical
(B) Real-Time Kinematic (RTK) GPS for centimeter-level positioning
(C) Rotary atomizers or fine nozzles for controlled droplet application
(D) Multi-spectral optical sensors for crop-weed differentiation

2012
150. A farmer evaluating a new integrated weed management technique using partial budgeting determines that the added costs are \$50/ha, the reduced costs are \$10/ha, the added returns are \$100/ha, and the reduced returns are \$0/ha. What is the net change in profit?
(A) -\$40/ha
(B) +\$40/ha
(C) +\$60/ha
(D) +\$110/ha

2017
151. Identify the INCORRECT statement regarding physical seed dormancy caused by a hard seed coat.
(A) It is an irreversible condition that permanently prevents germination.
(B) It prevents the imbibition of water required for germination.
(C) It restricts the diffusion of oxygen to the embryo.

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(D) It provides mechanical resistance against embryo expansion.

2008

152. Weed seeds are frequently found lodged in the mud attached to the tires of agricultural tractors. This mode of dispersal strongly infers the importance of which control measure?
(A) Applying higher rates of foliar herbicides
(B) Increasing the depth of crop seed placement
(C) Transitioning entirely to zero-tillage agriculture
(D) Cleaning farm machinery before moving between fields

2001

153. A weed species that strictly thrives in acidic, waterlogged soils and struggles to survive in well-drained, alkaline fields is exhibiting traits fundamental to which classification system?
(A) Ontogeny-based biological classification
(B) Ecology and soil-type classification
(C) Cotyledon-based morphology classification
(D) Geographic origin-based classification

2003

154. In crop-weed interference, the concept of "competitive threshold" or "damage boundary" is primarily determined by evaluating:
(A) The total cumulative mass of chemical herbicide applied
(B) The vertical depth profile of the active soil seed bank
(C) The crop-weed density ratio and duration of coexistence
(D) The physical color and morphology of mature weed flowers

2017

155. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The Weed Index (WI) calculates the percentage yield loss suffered by a crop due to weed competition, relative to a completely weed-free check.
Reason (R): A higher Weed Index value indicates highly effective weed management in the treated plot.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

156. The active exudation of sorgoleone from the roots of Sorghum bicolor directly causes:
(A) Severe allelopathic inhibition of small-seeded broadleaf weeds
(B) Rapid chemical stimulation of parasitic weed seed germination processes
(C) A significant decrease in overall soil aggregate structural stability
(D) Immediate vertical volatilization of residual soil-applied herbicides

2013

157. In weed ecology, the term "weed flora climax" refers to:
(A) The immediate emergence of weeds following the first monsoon rain
(B) A stable weed community adapted to a long-term agronomic practice
(C) The point at which all weed seeds in the soil have successfully germinated
(D) The rapid die-off of annual weeds at the end of the winter season

2021

158. Which of the following does NOT correctly pair an herbicide with its chemical family?
(A) Atrazine - Triazine
(B) Glyphosate - Sulfonylurea
(C) Pendimethalin - Dinitroaniline
(D) 2,4-D - Phenoxycarboxylic acid

2022

159. Identify the correct statement regarding Wettable Powder (WP) herbicide formulations.
(A) Finely ground solid particles forming a water suspension that requires continuous tank agitation
(B) Chemical formulations that dissolve completely to form a transparent true solution in the tank
(C) Liquid-based concentrates that are highly flammable and require specialized storage containers
(D) Formulations that are entirely unaffected by moderate wind currents during field mixing operations

NODIA

2008

160. Applying a synthetic auxin herbicide (like 2,4-D) to a susceptible dicot weed primarily causes:
(A) Immediate, localized cell membrane destruction resulting in rapid foliar desiccation
(B) Rapid, systemic bleaching and chlorosis of newly emerging terminal vegetative foliage

(C) Abnormal cell division and elongation, causing severe epinasty and twisted growth
(D) Complete cessation of root elongation without exhibiting any early visible foliar symptoms

2019
161. Placing an herbicide chemically bound to a large granule directly onto the soil surface, while planting the crop seed deeply in untreated soil below, is an application of:
(A) Biochemical enzyme-based selectivity
(B) Physiological in-planta selectivity
(C) Transgenic target-site tolerance
(D) Positional depth-based selectivity

2009
162. A known molecular mechanism contributing to enhanced herbicide resistance, beyond simple point mutations, involves the weed genome replicating the target enzyme gene multiple times. This is termed:
(A) Vacuolar compartmentalization
(B) Epigenetic silencing
(C) Target-site gene amplification
(D) Conjugative detoxification

2013
163. The lateral movement of dissolved herbicide molecules across the soil surface, typically entrained in water following heavy precipitation, is defined as:
(A) Desorption
(B) Runoff
(C) Deep percolation
(D) Volatilization

2006
164. Which of the following is NOT a recognized phase of in-plant herbicide metabolism?
(A) Phase I: Oxidation, reduction, or hydrolysis to expose reactive functional groups
(B) Phase II: Conjugation with plant sugars, amino acids, or glutathione
(C) Phase III: Sequestration of the conjugate into the vacuole or cell wall
(D) Photolytic fragmentation of the carbon skeleton via chloroplast UV emission

2017
165. Match the sprayer components in List I with their primary functions in List II.
List I: Sprayer components
P. Pump
Q. Agitator
R. Pressure Regulator (Relief Valve)
S. Nozzle
List II: Primary functions
1. Controls and maintains uniform application pressure in the boom
2. Atomizes the liquid into spray droplets and determines the spray pattern
3. Creates the flow and pressure required to move the liquid
4. Keeps WP and flowable formulations uniformly suspended in the tank
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-4, Q-1, R-2, S-3

2009
166. A classical biological control agent (e.g., a weevil) successfully established on an invasive weed in a new country. One can strongly infer that this success was due to the agent:
(A) Being capable of feeding extensively on multiple native economic crop species
(B) Being highly sensitive to localized seasonal climatic and temperature extremes
(C) Lacking any natural predators or parasitoids in the introduced environment
(D) Possessing a very low reproductive rate and restricted geographic dispersal

2017
167. The commercial field application of a mycoherbicide is severely constrained by its microclimatic requirements. Applying it during a hot, dry afternoon will cause:
(A) Spore desiccation, causing failure to germinate and penetrate the cuticle
(B) Rapid, systemic translocation of fungal toxins throughout the weed's phloem tissue
(C) Instantaneous, UV-induced genetic mutation of the applied beneficial fungal strain
(D) Extensive physical and chemical degradation of the vegetative fungal cell wall structures

2012
168. The "stale seedbed" technique involves preparing the land, allowing the first flush of weeds to germinate, and then destroying them before planting the main crop. This approach aims to:
(A) Significantly increase the total number of highly dormant weed seeds in the profile
(B) Enhance the efficacy of soil-applied pre-emergence residual herbicides exclusively
(C) Physically invert the entire topsoil profile up to thirty centimeters deep using plows
(D) Deplete the surface seed bank without

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disturbing deeper seeds

2006

169. Witchweed (Striga spp.) is an obligate parasitic weed. Biologically, it attaches itself to the host plant's:
(A) Inflorescence
(B) Root system
(C) Upper stem and leaves
(D) Developing seeds

2001

170. Identify the INCORRECT statement regarding the mechanical management of aquatic weeds.
(A) Harvesting aquatic weeds removes immense volumes of biomass from the water body.
(B) Dredging physically removes submerged weed roots and tubers from the benthic mud.
(C) Mechanical cutting provides permanent eradication of perennial aquatic weeds like Hydrilla.
(D) The harvested aquatic biomass can sometimes be utilized for composting or biogas production.

2019

171. The application window for a "pre-emergence" herbicide in a field crop is defined precisely as the period:
(A) Directly before the primary mechanical tillage operations are completed in the field
(B) Directly after the planted crop has successfully established its third true leaf stage
(C) When the mature weed seeds are fully formed and viable on the parent weed plant structure
(D) After sowing the crop but before the emergence of crop and weed seedlings

2002

172. Which of the following is NOT an advantage of using organic mulches in horticultural weed management?
(A) They actively and permanently sterilize the soil microbiome.
(B) They suppress weed germination by blocking light.
(C) They increase soil moisture retention.
(D) They contribute organic matter to the soil upon decomposition.

2002

173. The cultivation of closely related wild species adjacent to fields of Herbicide-Tolerant (HT) crops creates a high risk of:
(A) Significantly reduced economic crop yield driven by chemical root allelopathy
(B) HT gene transfer into wild species via pollen-mediated gene flow
(C) The engineered HT crop spontaneously reverting to a non-transgenic wild state
(D) Spontaneous, unpredictable genetic mutations in the surrounding soil microbiome

2013

174. A precision agriculture system uses weed maps generated by drone imagery to control a sprayer that dynamically adjusts the herbicide dose as it moves across the field. This specific technology is known as:
(A) Global Positioning System (GPS)
(B) Variable Rate Technology (VRT)
(C) Geographic Information System (GIS)
(D) Telemetry

2025

175. Select the correct logical sequence for conducting a Cost-Benefit Ratio (CBR) analysis of a new weed management practice.
(A) Calculate Net Returns → Calculate Total Costs → Calculate Gross Returns → Divide Net by Total Costs
(B) Calculate Gross Returns → Calculate Variable Costs → Calculate Fixed Costs → Subtract Costs from Returns
(C) Calculate Total Costs → Calculate Gross Returns → Calculate Net Returns → Divide Gross Returns by Total Costs
(D) Calculate Total Cost of Cultivation → Calculate Gross Returns from Yield → Divide Gross Returns by Total Cost

2023

176. Some small-seeded weed species, like Portulaca oleracea, require exposure to red light to break dormancy. This physiological requirement ensures that the seeds germinate only when they are:
(A) Buried deep within the anaerobic soil profile
(B) Subjected to prolonged freezing temperatures
(C) Located at or very near the soil surface
(D) Placed in heavily shaded, dense crop canopies

2005

177. The proliferation of irrigation canals throughout an arid agricultural region directly causes a massive increase in weed dispersal via:
(A) Epizoochory
(B) Anemochory
(C) Barochory

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(D) Hydrochory

2025
178. Identify the correct grouping based strictly on the ecological classification of weeds.
(A) Annuals, Biennials, Perennials
(B) Grasses, Sedges, Broadleaves
(C) Arable, aquatic, and ruderal weeds
(D) Noxious, Invasive, Quarantine

2016
179. In weed science, the term "interference" encompasses:
(A) Only the physical competition for limited environmental resources
(B) Combined effects of resource competition and chemical allelopathy
(C) Only the chemical inhibition of crops via allelopathy
(D) The parasitism of crops by obligate root parasites exclusively

2006
180. Which of the following is an INCORRECT distinction between the Damage Boundary and the Economic Threshold Level (ETL)?
(A) The Damage Boundary is the weed density where measurable yield loss first occurs.
(B) ETL is the density where control costs equal the value of yield saved.
(C) Control measures are theoretically justified only at or above the ETL, not merely at the Damage Boundary.
(D) The Damage Boundary fluctuates with crop market prices, while ETL is biologically fixed.

2024
181. The release of volatile allelochemicals (e.g., terpenes from Salvia species) is most effective and widespread in which type of environment?
(A) Arid environments with high temperatures
(B) Waterlogged, flooded anaerobic paddy fields
(C) Extremely cold, frozen polar tundra soils
(D) Deep, compacted heavy clay agricultural soils

2024
182. A long-term shift from conventional tillage to minimum tillage typically results in an increased dominance of:
(A) Large-seeded annual dicots
(B) Deep-rooted, tuber-producing species dependent on fragmentation
(C) Wind-dispersed annuals and simple perennials like dandelions
(D) Obligate aquatic weeds

2012
183. Bipyridylium herbicides (e.g., paraquat) act as Photosystem I (PSI) electron diverters. Their application in bright sunlight causes:
(A) Rapid production of free radicals, destroying cell membranes and causing foliar desiccation
(B) Slow, progressive systemic necrosis of the entire root system occurring over several weeks
(C) Complete enzymatic inhibition of critical amino acid synthesis in active meristematic zones
(D) Extensive leaf cell distortion, severe petiole epinasty, and twisted vegetative growth

2012
184. From the composition of an Emulsifiable Concentrate (EC), one can infer that if the emulsifier breaks down during storage, the formulation will likely:
(A) Form hard, completely insoluble solid granules at the bottom of the tank
(B) Immediately and rapidly volatilize out of the sealed storage container
(C) Spontaneously convert into a dry, highly water-soluble chemical powder
(D) Separate into distinct oil and solvent layers, causing uneven application

NODIA

2001
185. Consider the following statements regarding HPPD inhibitor herbicides (e.g., mesotrione):
I. They block the synthesis of plastoquinone, leading to a massive destruction of carotenoids.
II. They induce rapid cell division and epinasty in grasses.
III. The primary visual symptom on susceptible weeds is extreme bleaching (whitening) of new growth.
IV. They are widely used for selective broadleaf weed control in maize.
Which of the above statements is/are incorrect?
(A) I and III
(B) II only
(C) III and IV
(D) I and IV

2008
186. Physiological age-based selectivity explains why:
(A) Pre-emergence soil-applied herbicides selectively kill weed seeds without harming larger crop seeds.

(B) Crops possess specialized enzymes to metabolize herbicides rapidly while target weed species do not.
(C) Mature weeds with thick cuticles are less sensitive than young, active seedlings.
(D) Deep-rooted perennial crops avoid direct herbicide contact zone within the topsoil layer entirely.

2006

187. Identify the INCORRECT statement regarding the management of herbicide resistance.
(A) Rotating between different herbicide modes of action delays resistance evolution.
(B) Tank-mixing two effective herbicides with different modes of action is a recommended strategy.
(C) Integrating cultural and mechanical control methods reduces the selection pressure on chemical herbicides.
(D) Continuously utilizing a single, highly effective herbicide at lower-than-recommended doses prevents resistance from developing.

2012

188. Soils possessing high cation exchange capacity (CEC) and high organic matter dictate that soil-applied pre-emergence herbicides must be applied at:
(A) Higher rates, because more active ingredient is adsorbed and unavailable for weed uptake
(B) Lower rates, because the dissolved chemical herbicide will leach instantly through the soil profile
(C) Lower rates, because the active organic molecule is strongly repelled by soil organic matter fractions
(D) The exact same application rate as typically recommended for pure coarse-textured sandy soils

2025

189. Co-metabolism in the context of herbicide degradation in soil refers to:
(A) The spontaneous, non-enzymatic chemical reaction occurring between two different herbicides in a tank mix
(B) Microbial degradation where the microbe derives no energy or carbon from the herbicide
(C) The simultaneous passive uptake of water and dissolved chemical herbicide molecules by plant root systems
(D) The synergistic pathological action of a chemical herbicide and an endemic fungal pathogen on a weed leaf

2002

190. For an even broadcast application of herbicides across a bare soil surface, the boom sprayer must be fitted with nozzles producing a specific pattern. Which pattern is correct?
(A) Solid stream
(B) Tapered flat fan
(C) Hollow cone
(D) Off-center flood

2018

191. In biological weed control, the "host specificity" of an agent refers to its:
(A) Biological restriction to feeding and reproducing only on the target weed
(B) The physiological ability to survive extreme local temperature and climatic variations
(C) The capacity for rapid population expansion and extensive regional geographic dispersal
(D) The daily rate of physical consumption of green vegetative weed biomass by the agent

2013

192. Which factor does NOT represent a major constraint in the commercialization of bio-herbicides?
(A) Stringent environmental requirements (humidity, temperature) for field efficacy
(B) Short shelf-life of the living formatted product
(C) Broad-spectrum activity capable of killing multiple weed families simultaneously
(D) High production costs compared to synthetic chemicals

2017

193. Identify the correct statement regarding crop density and weed management.
(A) Lowering crop density universally increases crop yield by reducing intraspecific competition.
(B) Crop density has absolutely no effect on the Critical Period of Weed Control.
(C) Wide row spacing is the most effective cultural method to eliminate light penetration to the soil.
(D) Maintaining optimum to slightly higher crop plant populations promotes rapid canopy closure, which efficiently suppresses late-emerging weeds.

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2002

194. Catch crops or trap crops are integrated into the management of parasitic weeds like Striga primarily because they:
(A) Physically shade out and suppress the development of the parasite prior to its soil emergence
(B) Actively absorb and completely neutralize soil-applied herbicides before they reach the parasite
(C) Exude stimulants inducing suicidal germination of parasite seeds without hosting them
(D) Produce massive amounts of aboveground dry biomass that act as a highly effective physical mulch

2016

195. Consider the following statements concerning the biological control of aquatic weeds:
I. The introduction of the Neochetina weevil successfully managed water hyacinth in many regions.
II. Grass carp (Ctenopharyngodon idella) is a non-selective herbivorous fish used to clear submerged aquatic weeds.
III. Bio-control agents for aquatic weeds never require host-specificity testing.
IV. Aquatic environments provide a stable microclimate, often enhancing the establishment of bio-control agents.
V. Classical bio-control provides instantaneous eradication of aquatic weeds.
Which of the above statements are correct?
(A) I, II and V
(B) I, II and IV
(C) II, III and IV
(D) I, III and V

2013

196. Standard weed control schedules often involve herbicide tank mixtures. The primary rationale for mixing two compatible herbicides is to:
(A) Increase the volatility of both chemicals
(B) Decrease the physical solubility of the active ingredients
(C) Induce immediate phytotoxicity in the crop to stunt its growth
(D) Broaden the spectrum of weed species controlled in a single pass

2012

197. In high-value drip-irrigated orchard crops, weeds heavily concentrate directly beneath the emitters. One can infer that the most efficient, targeted chemical management strategy is:
(A) Herbigation by injecting herbicides directly through the drip irrigation system
(B) Aerial broadcast application of liquid droplets using specialized agricultural airplanes
(C) Widespread, continuous deep moldboard plowing across the entire active orchard floor
(D) Manual slashing or mowing of weed growth strictly once during the entire cropping year

2025

198. Volunteer crops originating from the previous season's Herbicide-Tolerant (HT) crop pose a unique weed management challenge because:
(A) They possess highly specialized, absolute physical dormancy mechanisms lasting for exactly one decade.
(B) They completely lack all basic biological and physiological competitive traits compared to wild weeds.
(C) They cannot be controlled by the specific herbicide to which they were engineered to be tolerant, necessitating an alternate mode of action.
(D) They actively release highly toxic, localized root allelochemicals that completely kill the current crop.

NODIA

2016

199. Advanced machine vision systems in precision agriculture utilize convolutional neural networks (CNNs) to:
(A) Detect, classify, and map distinct weed species in real-time within crop canopies
(B) Directly vaporize emerging weed tissues using high-energy, precisely directed lasers
(C) Mechanically sever aggressive weed roots at a highly uniform depth across the field
(D) Accurately measure the exact volumetric soil moisture content across the crop profile

2016

200. A limitation of using the Cost-Benefit Ratio (CBR) exclusively to evaluate integrated weed management strategies is that CBR:
(A) Highlights the profitability per unit of investment effectively
(B) Can easily be calculated from basic input and yield data
(C) Often ignores long-term unquantified ecological benefits, focusing solely on immediate monetary returns
(D) Accounts for environmental and ecological

sustainability benefits like reduced resistance risk

2006

201. Identify the correct mechanism that breaks innate physiological dormancy in many temperate weed seeds.
(A) Direct exposure of the seed coat to boiling water for highly extended periods of time
(B) After-ripening, allowing internal chemical inhibitors to dissipate during dry storage
(C) Immediate deep physical burial of the seed within highly anaerobic waterlogged soils
(D) Physical puncturing and enzymatic degradation of the hard seed coat by localized soil fungi

2007

202. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Weed seeds possessing a pappus or wing structures exhibit highly efficient dispersal dynamics across fragmented agricultural landscapes.
Reason (R): These specialized appendages drastically increase the aerodynamic drag of the seed, allowing it to be carried over vast distances by wind currents (anemochory).
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

203. The invasive nature of alien weeds like Lantana camara in new environments is heavily driven by the "Enemy Release Hypothesis," which causes the weed to:
(A) Rapidly lose all of its internal defensive allelochemical production pathways over generations
(B) Revert to a completely non-competitive, highly dormant state within the introduced soil profile
(C) Become obligately and strictly dependent on native generalist insect pollinators for survival
(D) Divert resources into growth and reproduction due to the absence of co-evolved herbivores

2005

204. Calculating the Critical Period of Weed Control (CPWC) requires modeling two distinct curves over time: the critical weed-free period and the:
(A) Critical time of weed removal
(B) Degradation curve of a pre-emergence herbicide
(C) Soil moisture depletion curve
(D) Photoperiodic response curve of the crop

2009

205. Match the damage or threshold concept in List I with its defining characteristic in List II.
List I: Damage or threshold concept
P. Damage Boundary
Q. Economic Threshold Level (ETL)
R. Action Threshold
S. Aesthetic Threshold
List II: Defining characteristic
1. The density at which control measures must be initiated to prevent the population from reaching ETL
2. The minimum weed density that causes a statistically significant yield reduction
3. Used in turf or ornamental settings where visual appearance dictates control, regardless of yield
4. The density at which control costs equal the monetary value of the yield saved
(A) P-1, Q-4, R-2, S-3
(B) P-2, Q-4, R-1, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

2012

206. True allelopathy is distinguished from functional allelopathy based on the fact that in true allelopathy:
(A) The chemical compounds are synthesized strictly by soil microbes
(B) The allelochemicals are released from the plant in their toxic, active form
(C) The chemical strictly acts as a nutrient source for the receiver plant
(D) The precursor chemicals require microbial transformation in the soil to become toxic

2022

207. Which factor does NOT significantly drive the successional dynamics of weed flora in a continuous cropping system?
(A) The phase of the moon during the planting of the crop seed
(B) The repetitive use of herbicides with the same mode of action

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(C) The specific timing and intensity of mechanical tillage operations
(D) Crop rotation sequences that alter the light and moisture environment

2007

208. Arrange the following major herbicide groups in the chronological order of their historical discovery and commercialization:
I. EPSPS inhibitors (e.g., Glyphosate)
II. Inorganic salts (e.g., Copper sulfate)
III. Synthetic auxins (e.g., 2,4-D)
IV. ALS inhibitors (e.g., Sulfonylureas)
Which of the following represents the correct chronological order?
(A) II, III, I, IV
(B) I, II, III, IV
(C) III, II, IV, I
(D) II, I, III, IV

2009

209. A Suspension Concentrate (SC) herbicide formulation is technically defined as:
(A) A highly volatile chemical gas compressed under pressure into a liquid state
(B) An oil-based active ingredient dissolved completely within an organic solvent system
(C) A dry finely ground powder requiring extensive formulation with inert clay carriers
(D) Fine solid particles of active ingredient suspended stably in a liquid medium

NODIA

2003

210. Protox (PPO) inhibitor herbicides applied post-emergence cause rapid necrosis and desiccation of weed foliage. This rapid tissue death is a direct consequence of:
(A) The immediate, complete cessation of root elongation and cellular division in roots
(B) The slow, progressive depletion of internal structural carbohydrate reserves over time
(C) Accumulation of reactive oxygen species destroying cell membranes via lipid peroxidation
(D) The rapid, physical stomatal closure completely preventing localized carbon assimilation

****

ANSWERS

1. (D) Dormancy induced after dispersal due to unfavorable environmental conditions
Secondary dormancy is an acquired physiological state of seed arrest triggered by adverse environmental factors after shedding. Unlike primary dormancy, which is genetically determined before dispersal, this mechanism acts as an ecological survival strategy. It prevents premature germination when moisture, temperature, or oxygen levels are unfavorable, ensuring long-term seed persistence within the soil bank.

2. (C) Epizoochory
Epizoochory describes the external dispersal of plant seeds via animal vectors. Seeds utilizing this mechanism typically possess specialized structural adaptations, such as hooks, barbs, spines, or sticky secretions. These physical structures facilitate secure attachment to animal fur, feathers, or human clothing, allowing the seeds to be transported long distances before eventually detaching in new habitats.

3. (B) Apophytes
Apophytes are native plant species that successfully adapt to human-disturbed habitats and behave as weeds. While invasive alien weeds originate from foreign regions, these native species shift from their natural ecological niches into agricultural fields, roadsides, or managed landscapes. This transition occurs because anthropogenic disturbances create favorable conditions that match their inherent growth and survival capabilities.

4. (D) It generally begins at the time of crop emergence and extends until crop physiological maturity.
The critical period of weed control is a specific window within the crop cycle during which weed competition causes severe yield losses. It does not span the entire duration from crop emergence to physiological maturity. Instead, it represents a defined intermediate timeframe when weed suppression is economically essential to protect the final harvest yield and quality.

5. (B) I and II
Weed control efficiency measures the reduction in weed biomass achieved by a specific management practice compared to an untreated control. Similarly, the weed index quantifies the percentage yield loss directly attributable to weed competition relative to a completely weed-free treatment. The damage boundary is the weed density where measurable crop yield loss first begins to occur.

6. (C) True allelopathy via volatilization
True allelopathy occurs when a plant releases primary bioactive chemical compounds directly into the surrounding environment in their active form. When these phytotoxic compounds are discharged as gaseous vapors from foliage into the atmosphere, the mechanism is specifically classified as volatilization. This process inhibits the physiological development and germination of neighboring susceptible weed species.

7. (A) Long-term adoption of zero-tillage practices
Zero-tillage practices eliminate mechanical soil disturbance, creating an ideal environment for perennial weed species to establish. Without plowing to sever roots, stolons, rhizomes, or tubers, these weeds accumulate reserves and spread. Consequently, the weed community shifts from annual species, which rely on soil disruption for germination, toward highly persistent and competitive perennial weeds.

8. (D) Inhibiting the acetolactate synthase (ALS) enzyme
Sulfonylureas and imidazolinones are distinct herbicide chemical families that share a common physiological mode of action. Both groups selectively target and inhibit the acetolactate synthase enzyme inside susceptible plants. This enzymatic blockage halts the biosynthesis of critical branched-chain amino acids, specifically valine, leucine, and isoleucine, which immediately disrupts cell division and plant growth.

9. (B) To allow the oil-soluble active ingredient to form stable micro-droplets in water
Emulsifying agents in emulsifiable concentrate formulations are essential surface-active

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compounds. They reduce the interfacial tension between the organic solvent containing the active ingredient and the aqueous carrier. This physical action allows the hydrophobic, oil-soluble pesticide to disperse uniformly as stable micro-droplets throughout the water, ensuring a homogeneous spray mixture during application.

10. (C) Disruption of microtubule assembly during mitosis
Dinitroaniline herbicides, such as pendimethalin, exert their phytotoxic effects by binding specifically to tubulin proteins in plant cells. This binding inhibits the polymerization of tubulin, which completely disrupts the assembly of microtubules necessary for spindle fiber formation during mitosis. Consequently, cell division halts in meristematic tissues, preventing root and shoot elongation.

11. (D) Exudation of the intact herbicide through the stomata
Crop selectivity to herbicides depends on complex internal physiological and biochemical processes. Recognized mechanisms include rapid metabolic detoxification via enzymes, physical compartmentalization of the chemical inside vacuoles, and restricted translocation away from the target site. However, plants do not actively or physiologically exude intact, unmetabolized herbicide molecules through their stomatal openings to achieve tolerance.

12. (A) Cross-resistance involves one mechanism for multiple herbicides, whereas multiple resistance involves several distinct mechanisms.
Cross-resistance occurs when a single biochemical mechanism, such as a modified target site or enhanced metabolism, protects a plant against several different herbicides. Conversely, multiple resistance arises when a weed population accumulates two or more distinct resistance mechanisms, enabling individuals to survive treatments from multiple herbicide classes with completely different modes of action.

13. (B) Increased soil adsorption and reduced bioavailability
High soil organic matter significantly increases the number of available hydrophobic binding sites on soil colloids. Non-polar herbicides chemically adsorb to this organic fraction through hydrophobic interactions, reducing their concentration in the soil solution. This strong adsorption decreases the bioavailability of the herbicide for plant root uptake, often necessitating higher application rates for effective control.

14. (B) Microbial breakdown
Microbial breakdown is the primary degradation pathway for thiocarbamate herbicides in warm, moist soils. Soil microorganisms, including bacteria and fungi, utilize these organic compounds as metabolic substrates, enzymatically cleaving the chemical bonds. Under favorable warm and humid conditions, microbial activity peaks, rapidly reducing herbicide persistence and sometimes leading to accelerated degradation upon repeated applications.

NODIA

15. (A) Both A and R are true and R is the correct explanation of A.
Flat fan nozzles are specifically engineered to produce a tapered, flat spray sheet. When aligned correctly along a boom, their overlapping spray patterns ensure a highly uniform distribution of pre-emergence herbicides across the soil surface. This even coverage is critical for establishing a consistent chemical barrier, making them superior to hollow cone nozzles for soil applications.

16. (C) Applying massive doses of a native pathogen to achieve rapid, localized weed suppression
The inundative approach in biological weed control involves the periodic application of massive quantities of a biological agent, typically a native fungal pathogen. This method mimics chemical herbicide applications to achieve rapid, targeted suppression of the weed population. It does not rely on long-term agent establishment, but rather on immediate biological damage to the existing weed flora.

17. (D) Glyphosate
Mycoherbicides are commercial biological weed control formulations based on living fungal pathogens, such as Collego, Devine, and Biopolaris, which target specific weeds. Conversely, glyphosate is a synthetic chemical herbicide that inhibits the 5-enolpyruvylshikimate-3-phosphate synthase enzyme. It is not derived from or formulated using living fungal organisms, classifying it strictly as a chemical control agent.

18. (C) IWM restricts herbicide use exclusively to severe emergency situations.
Integrated Weed Management is a comprehensive, ecological approach that combines preventive, cultural, mechanical, and chemical control methods to keep weed populations below the economic threshold. It does not relegate herbicides solely to emergency use. Instead, chemical options are systematically integrated with other strategies to optimize long-term control, minimize resistance, and maintain economic and environmental sustainability.

19. (B) Crop phloem via the established haustorial connections
Parasitic weeds like Orobanche establish physical connections with their host plants using specialized organs called haustoria. Systemic herbicides absorbed by crop leaves translocate through the crop's phloem, following the source-to-sink flow of photoassimilates. These chemicals travel directly through the haustorial interface into the parasite's vascular system, accumulating at toxic levels to achieve control.

20. (D) Floating
Water hyacinth is a highly invasive aquatic weed characterized by its free-floating growth habit. The plant possesses specialized bulbous, spongy petioles filled with air spaces that provide buoyancy, allowing it to float freely on the water surface. It does not anchor its root system into the bottom sediment, distinguishing it from submerged or emergent species.

21. (A) Pre-emergence pretilachlor followed by post-emergence bispyribac-sodium
Managing complex weed flora in transplanted rice requires a sequential herbicide program to target different emergence windows. An early pre-emergence application of pretilachlor controls annual grasses and broadleaves during initial crop establishment. A subsequent post-emergence application of bispyribac-sodium effectively targets later-emerging weeds, ensuring comprehensive season-long control of diverse weed species under flooded conditions.

22. (C) Physically blocking emergence and light penetration
Plastic film mulching suppresses weed growth primarily by creating a physical and light-impenetrable barrier over the soil surface. This barrier blocks solar radiation, denying germinating weed seedlings the light required for photosynthesis. Deprived of light, the seedlings cannot sustain growth and quickly perish beneath the film, effectively controlling weeds without chemical inputs.

23. (A) Rapid selection of glyphosate-resistant weed biotypes
The widespread and continuous adoption of glyphosate-tolerant crops has placed intense, uniform selection pressure on local weed populations. Over time, individuals possessing natural mutations or mechanisms that survive glyphosate exposure survive and reproduce. This process has led to the rapid selection and proliferation of glyphosate-resistant weed biotypes globally, presenting a major challenge to modern agronomic systems.

NODIA

24. (D) Machine vision using spectral and morphological analysis
Precision weed management utilizes advanced machine vision systems to achieve real-time weed detection and differentiation. These systems capture high-resolution images of the field canopy, analyzing specific plant morphological characteristics like leaf shape alongside spectral reflectance signatures. This analysis allows real-time discrimination between cultivated crop foliage and surrounding weeds, facilitating targeted, site-specific herbicide micro-applications.

25. (B) P-3, Q-1, R-4, S-2
Evaluating the economics of weed management involves key financial concepts. The cost-benefit ratio divides gross returns by total costs. Partial budgeting compares the financial consequences of shifting from one practice to another. The economic threshold is the weed density where control costs equal preserved yield value, while the damage boundary is where yield loss becomes statistically measurable.

26. (C) Rhizomes
Rhizomes are specialized, horizontal underground stems that function in vegetative propagation and food storage for perennial plants like Cynodon dactylon. Unlike stolons, which grow above the soil surface, rhizomes grow subterraneanly, producing adventitious roots and shoots from their nodes. This underground structure allows the plant to survive severe environmental stresses and mechanical tillage.

27. (D) It utilizes seed buoyancy for transport via irrigation water.
Hydrochory is the scientific term for weed seed dispersal mediated by water. This transport mechanism relies heavily on specific physical adaptations of seeds, such as low density, air-filled structures, or waxy coatings that provide long-term buoyancy. These traits allow seeds to float and travel along irrigation canals, surface runoff, or rivers to colonize new fields.

28. (A) It is defined strictly by its evolutionary origin.
A noxious weed is defined by its legal status and economic impact rather than its evolutionary origin. These weeds are highly destructive and invasive species regulated by quarantine laws. Because they pose severe threats to agricultural productivity, livestock health, or native ecosystems, their management and containment are legally mandated and enforced by state or national authorities.

29. (B) Light
When a tall, broad-leaved weed species rapidly overtops a shorter crop early in the growing season, it creates a physical canopy barrier that intercepts solar radiation. This shading directly deprives the shorter crop of light, which is crucial for photosynthesis. Consequently, the crop's vegetative development is severely stunted, leading to a significant reduction in yield.

30. (B) 80%
Weed Control Efficiency is calculated by subtracting the treated plot weed dry weight from the untreated control weight, dividing by the control weight, and multiplying by one hundred. For five hundred and one hundred kilograms, the biomass reduction is four hundred kilograms. Dividing by five hundred yields zero point eight, which equals an eighty percent efficiency.

31. (A) Phenolic acids
Allelochemicals are bioactive secondary metabolites synthesized by plants that influence the growth and development of neighboring vegetation. Phenolic acids represent a major class of these compounds, commonly released through root exudation, foliage leaching, or residue decomposition. Unlike primary metabolites like carbohydrates and cellulose, these secondary compounds possess strong phytotoxic properties that suppress weed seed germination.

32. (C) Deep-rooted perennials are completely eliminated without mechanical tillage.
Under continuous conservation agriculture with zero tillage, the lack of mechanical soil inversion prevents the physical disruption of perennial root systems. Consequently, deep-rooted perennial weeds are not eliminated; instead, they often increase and become dominant. The soil surface accumulation of organic matter and seeds favors small-seeded annuals, while the absence of tillage allows perennials to flourish.

33. (D) Photodegradation and vapor loss
Pre-plant incorporation is an application method where herbicides are mechanically mixed into the soil surface immediately after spraying. This practice is essential for highly volatile chemicals or those sensitive to solar radiation. By placing the herbicide molecules beneath the soil surface, the chemical is physically protected from rapid photodegradation and atmospheric loss via volatilization.

34. (C) Decrease droplet surface tension to improve leaf coverage
Surfactants are surface-active adjuvants added to herbicide formulations to modify the physical properties of the spray solution. They function by significantly lowering the interfacial surface tension of individual spray droplets. This physical modification prevents the droplets from rolling off hydrophobic waxy leaf cuticles, allowing them to spread widely and maximize chemical contact and absorption.

35. (D) II only
Acetyl-CoA carboxylase inhibitor herbicides, commonly known as graminicides, selectively target monocotyledonous grass species by disrupting fatty acid synthesis in their meristems. They do not affect dicotyledonous broadleaf species, which possess an insensitive prokaryotic-type enzyme form. Conversely, synthetic auxins target broadleaves, while ALS and EPSPS inhibitors block amino acid biosynthesis across susceptible species.

36. (D) Compartmentalization
Compartmentalization is a physiological tolerance mechanism where plant cells actively isolate absorbed toxic herbicide molecules inside the large central vacuole. By transporting and binding the active chemical away from sensitive metabolic pathways in the cytoplasm

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or chloroplasts, the cell protects its enzymatic target sites from inhibition, preventing cellular damage and ensuring plant survival.

37. (A) Broad resistance to entirely different modes of action
Target-site mutation resistance is a highly specific mechanism where a single nucleotide polymorphism alters the amino acid sequence of the target enzyme. This physical change prevents the herbicide from binding to its active site, but the resistance is typically restricted to that specific chemical class. It does not confer broad resistance to entirely different, unrelated modes of action.

38. (C) Leaching
Leaching describes the physical downward movement of dissolved chemical residues through the soil profile, primarily driven by percolating water from rainfall or irrigation. This transport process is highly pronounced for water-soluble, weakly adsorbed herbicides in coarse-textured sandy soils. Excessive leaching reduces herbicide concentration in the weed seed zone and increases groundwater contamination risks.

39. (A) Chemical hydrolysis
Chemical hydrolysis is an abiotic degradation pathway where an herbicide molecule undergoes chemical cleavage upon reacting with water molecules. This non-biological reaction is strongly influenced by soil temperature and chemical conditions, particularly extreme pH levels, rather than microbial enzymes. It breaks down active ingredients into non-toxic metabolites, directly affecting the persistence and efficacy of soil-applied herbicides.

40. (D) Flat fan nozzle
Flat fan nozzles are widely recommended for the broadcast application of herbicides. These specialized nozzles produce a flat, tapered spray pattern that, when overlapped across a spray boom, ensures highly uniform coverage on both the soil surface and plant foliage. They minimize drift by producing optimized droplet sizes suitable for contact and systemic herbicides.

41. (B) It introduces exotic enemies to permanently suppress invasive weeds.
Classical biological weed control involves identifying, importing, and releasing host-specific exotic natural enemies from the weed's native range into the introduced environment. This strategy aims to establish self-sustaining agent populations that permanently suppress the invasive weed density below economic thresholds. It does not seek rapid or total eradication, but rather a long-term, self-regulating ecological balance.

42. (C) A fungus targeting stranglervine
The biological herbicide formulation commercialized as Devine contains viable spores of the host-specific soil-borne fungus Phytophthora palmivora. It was developed to selectively target and control stranglervine within citrus orchards. When applied directly to the soil, this pathogen infects and kills the weed, offering an environmentally safe, targeted alternative to chemical herbicides.

43. (D) Employing a moldboard plow for deep inversion tillage
Cultural weed control methods modify the crop growing environment to favor crop growth and suppress weed development. Examples include adjusting plant densities, utilizing competitive cultivars, and modifying fertilizer application timing. Conversely, using a moldboard plow for deep soil inversion is classified as a physical or mechanical control method rather than a cultural practice.

44. (A) Cereals like sorghum, maize, and pearl millet
Striga asiatica is an obligate root parasite that infests major cereal crops such as sorghum, maize, sugarcane, and pearl millet. The weed seeds germinate only in response to specific root exudates released by host plants. Once germinated, the parasite penetrates the host root system to extract water, nutrients, and photoassimilates, causing severe crop stunting.

45. (B) Submerged → Floating → Emergent → Marginal
Aquatic plants colonize aquatic habitats along a distinct depth gradient extending from deep water to the shoreline. Submerged weeds grow entirely below the water surface in the deepest zones. Floating weeds occupy the surface of intermediate depths, while emergent weeds root in shallow water with aerial parts. Finally, marginal weeds populate the moist shorelines.

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46. (B) Malformation of roots and spikes
The selective systemic herbicide 2,4-D must be applied during a specific growth window in wheat, typically between thirty and thirty-five days after sowing. Applying this synthetic auxin too early, during initial seedling establishment, disrupts active cell division in embryonic tissues. This timing error causes severe physiological malformations, including tubular leaves, deformed roots, and distorted spikes.

47. (A) Maintaining a sod cover or utilizing directed post-emergence herbicide sprays
In perennial orchard systems, sustainable weed management avoids frequent deep tillage to prevent damaging shallow tree roots. Effective strategies involve maintaining a cover crop or sod cover to physically suppress weed emergence, protect the soil, and minimize erosion. This is combined with targeted, directed post-emergence herbicide applications to control weed patches under tree canopies.

48. (C) Trait introgression
Trait introgression is the process of transferring a specific transgenic trait, such as engineered herbicide tolerance, from a developed laboratory line into elite commercial agronomic cultivars. This is achieved through systematic backcrossing combined with molecular marker-assisted selection. This breeding approach ensures the resistance gene integrates stably into high-yielding, locally adapted crop varieties.

49. (D) It works well in completely obscured weed-crop canopies.
Machine vision technology relies on unobstructed optical sensors to analyze crop and weed characteristics in real-time. When crop and weed canopies overlap extensively, visual target boundaries become obscured, preventing the system from accurately differentiating leaf shapes and spectral signatures. This physical limitation reduces target recognition accuracy in dense, complex field environments.

50. (C) Less than 1.0
The incremental cost-benefit ratio is calculated by dividing additional revenue by additional cost. When the financial returns generated by a new herbicide program are less than the extra expenses incurred, the resulting quotient is less than one. This value indicates that the management shift is economically unviable and will reduce net farm profits.

51. (B) Absolute lack of light
Weed seed viability in the soil profile is influenced by biotic and abiotic factors. Deep burial isolates seeds, which reduces viability over time due to metabolic exhaustion, predation, and microbial decay. However, the complete absence of light does not harm seed longevity. Instead, darkness prevents germination, promoting a state of deep seed dormancy that preserves viability.

52. (D) Endozoochory
Endozoochory is the biological dispersal of plant seeds mediated internally by animal vectors. The process occurs when herbivores ingest seeds while feeding on plant tissues. The seeds possess tough coats that resist digestion in the intestinal tract. They are subsequently excreted intact in a distant location, facilitating geographic spread and colonization of new habitats.

53. (A) Quarantine weed
A quarantine weed is an invasive, destructive alien plant species that poses a severe threat to agricultural ecosystems but is not yet present, or is narrowly distributed, within a region. Government authorities legally list and monitor these species, enforcing strict inspection protocols on imported seed shipments to prevent their entry, establishment, and spread across borders.

54. (C) Early vegetative establishment
Competition for light between crops and weeds is most critical during early vegetative establishment. At this stage, rapid leaf area expansion and height development determine canopy dominance. Weeds that grow taller during this window intercept solar radiation, shading the crop and permanently restricting photosynthesis, which severely impacts the crop's long-term growth and eventual yield.

55. (B) II, III and V
The economic threshold level and damage boundary are distinct agronomic concepts. The damage boundary is a biological threshold representing the weed density where statistically measurable crop yield loss first occurs. Conversely, the economic threshold is an economic construct, varying with market prices and control costs,

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defining where weed control expenses equal the value of preserved yield.

56. (D) Inhibitory
Autotoxicity occurs when a plant synthesizes and releases toxic secondary metabolites that directly restrict the germination and development of its own seedlings. This physiological interaction is a specialized, self-inhibitory mechanism rather than a stimulatory or cooperative one. It acts as an ecological regulator, preventing over-crowding and intense resource competition among individuals of the same plant species.

57. (B) The flora shifts toward species naturally resistant to it.
The continuous, repeated application of a single herbicide mode of action imposes intense selection pressure on weed communities. Susceptible weed species are eliminated, which opens ecological niches and resources. Consequently, the local weed flora shifts over time toward species or biotypes that possess natural or acquired physiological mechanisms to tolerate that specific chemical.

58. (C) It translocates extensively to kill deep roots.
Contact herbicides exert their phytotoxic effects through localized, rapid chemical damage to the specific tissues they physically contact. Unlike systemic herbicides, they do not translocate through the plant's vascular system. Because of this physiological limitation, contact herbicides are unable to reach and destroy deep root systems, making them less effective against established perennial weeds.

59. (D) Phytotoxic crop leaf burn
Applying high concentrations of emulsifiable concentrate herbicides during periods of extreme temperature and low humidity increases chemical volatility and leaf penetration. Under these stressful atmospheric conditions, the organic solvents and active ingredients inside the formulation disrupt cell membranes. This cellular damage results in rapid localized necrosis and phytotoxic burn on the crop foliage.

60. (A) ALS inhibitor
Sulfonylurea herbicides selectively target the acetolactate synthase enzyme, halting the biosynthesis of essential branched-chain amino acids in susceptible plants. Without these building blocks, cell division stops immediately in meristematic tissues. Visible symptoms develop slowly, appearing as purpling, chlorosis, and gradual necrosis at the growing points within a week after herbicide exposure.

61. (B) Epicuticular wax layer thickness and composition
Differential absorption is a key morphological selectivity mechanism determining herbicide efficacy in crops. The thickness and chemical composition of the leaf epicuticular wax layer act as a physical barrier to foliar-applied herbicides. Crops possessing thick, waxy, or upright leaves absorb significantly less herbicide than weed species with thin, horizontal cuticles, conferring selective tolerance.

62. (B) Target-site mutation resistance
A single nucleotide change that alters the amino acid sequence of a target protein constitutes target-site mutation resistance. In this case, substituting glycine for serine at position two hundred and sixty-four in the D1 protein physically prevents the triazine herbicide from binding to its receptor. Because the target site is altered, the weed population survives treatment.

63. (A) Desorption
Desorption is the physical process where adsorbed chemical molecules detach from the surfaces of soil organic matter or clay minerals and enter the soil solution. This process is the reverse of adsorption. Desorption determines the concentration of bioavailable herbicide in soil water, directly influencing both root uptake by plants and the potential for leaching.

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64. (C) It increases when herbicides are incorporated into the soil.
Photodegradation is the abiotic chemical breakdown of herbicide molecules triggered by ultraviolet light energy. This degradation pathway strictly affects chemical residues exposed directly to solar radiation on the soil surface or plant foliage. Mechanically incorporating herbicides into the soil physically shields the chemical molecules from light, thereby reducing, rather than increasing, photodegradation.

65. (A) Both A and R are true and R is the correct explanation of A.
Calibrating a knapsack sprayer prior to herbicide application is essential to measure and verify the liquid volume delivered per unit area. This process ensures the precise application of recommended

chemical rates. Proper calibration prevents crop phytotoxicity caused by over-application, while also avoiding poor weed control resulting from under-dosing, making both statements true.

66. (C) Feeding on non-target crops or native flora
Conducting rigorous host-specificity testing is the most critical safety phase in classical biological weed control programs. Releasing an exotic biological control agent without this evaluation poses severe risks, as the organism may adapt to consume non-target crops or valuable native plant species. This feeding shift can cause unintended ecological damage and agricultural losses.

67. (B) Aeschynomene virginica (Northern jointvetch)
The commercial mycoherbicide known as Collego is formulated from living spores of the host-specific plant pathogenic fungus Colletotrichum gloeosporioides f. sp. aeschynomene. This bioherbicide is registered for the inundative control of Northern jointvetch, an invasive leguminous weed species. The pathogen infects stem tissues, causing lethal cankers that suppress the weed in rice fields.

68. (D) Preventive control
Cleaning agricultural machinery, such as combine harvesters, before moving them between fields is a fundamental preventive weed control practice. This sanitation measure physically removes weed seeds and vegetative propagules trapped in the equipment, blocking their transport to clean areas. Implementing preventive protocols is the most cost-effective strategy to stop the establishment of new infestations.

69. (A) It attaches to the host roots underground.
Cuscuta is a specialized stem holoparasitic plant that completely lacks developed foliage and photosynthetic chlorophyll. The parasite spreads aerial, thread-like stems that wrap around the shoots of host plants. It develops specialized structures called haustoria to penetrate the host's stem tissues, extracting moisture and nutrients. It does not attach to host roots underground.

70. (C) Submerged rooted weed
Hydrilla verticillata is ecologically classified as a submerged rooted weed. This invasive aquatic species anchors its root system into the bottom sediment of freshwater bodies, while its stems and whorled leaves develop entirely below the surface of the water. Its physiological adaptations allow it to perform photosynthesis efficiently under low-light, aquatic conditions.

71. (A) Deep taproots avoiding the treated zone (positional selectivity)
The selective use of pendimethalin in pulse crops relies on positional selectivity. Pendimethalin is applied to the soil surface, forming a concentrated chemical barrier in the shallow topsoil where small weed seeds germinate. Pulse crops, having large seeds and deep taproots, escape exposure because their active roots develop well below this toxic chemical zone.

72. (D) Perennial grasses like Imperata cylindrica
In established tea plantations, managing perennial grasses like Imperata cylindrica presents a severe agronomic challenge. These weeds possess extensive, deep-rooted rhizome systems that store energy and easily survive superficial hand weeding or contact herbicide applications. Their aggressive growth and high competition for resources can severely reduce tea crop productivity and plantation longevity.

73. (B) Glufosinate
The genetically modified Liberty Link trait provides crop tolerance to glufosinate, a broad-spectrum, non-selective contact herbicide. These transgenic crops express the pat or bar gene, which synthesizes the enzyme phosphinothricin acetyltransferase. This specialized enzyme metabolizes glufosinate into a non-toxic compound, protecting the crop while allowing post-emergence chemical control of surrounding weeds.

74. (C) Spraying in areas inaccessible to heavy ground machinery
Utilizing agricultural drones for herbicide spraying in undulating or steep terrains provides a major operational advantage. These aerial systems bypass ground obstacles, avoiding soil compaction and potential crop damage associated with heavy machinery. Drones can easily access and treat target areas on steep slopes or waterlogged fields where ground tractors cannot operate.

75. (C) P-1, Q-2, R-3, S-4
Economic evaluations are vital for determining the financial viability of agricultural practices.

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Gross return represents the total market value of the harvested crop. Variable costs include changing inputs, such as herbicide purchases and labor. Fixed costs are constant expenses like land rent, while net return is calculated by subtracting total costs from the gross returns.

76. (A) Stratification
Morphological seed dormancy is caused by an underdeveloped embryo at the time of seed dispersal. To overcome this physiological barrier, seeds typically require stratification, which involves exposure to specific temperature and moisture conditions over time. This treatment stimulates metabolic processes and hormone production, promoting embryo maturation and enabling subsequent germination.

77. (B) Human activities
Anthropochory describes the dispersal of weed seeds directly mediated by human activities. This mechanism includes the transport of weed seeds as contaminants in crop seed lots, on agricultural machinery, or via vehicles and clothing. Anthropochory is highly efficient, often moving seeds across vast geographical distances and facilitating the introduction of invasive species into new regions.

78. (B) Life cycle duration
Ontogeny refers to the developmental history and life cycle of an organism. An ontogeny-based classification categorizes weeds according to their biological life cycle duration. Under this system, weeds are grouped into annuals, biennials, or perennials based on whether they complete their growth, reproduction, and senescent phases within one, two, or multiple years.

79. (A) High soil moisture guarantees that light competition will not occur.
Crop-weed competition is a complex interaction involving multiple limited resources. While high soil moisture can minimize moisture stress, it does not prevent competition for light. In fact, abundant moisture often stimulates rapid weed vegetative growth and leaf expansion, increasing crop shading. Shading deprives the crop of light, which remains a critical limiting factor for photosynthesis.

80. (C) Decrease, justifying earlier control
The economic threshold level represents the weed density where the cost of control equals the value of saved crop yield. When the market price of a crop increases, the monetary value of the potential yield loss rises. Consequently, even low weed densities can cause economically significant damage, decreasing the threshold and justifying earlier management interventions.

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81. (D) Absorption of neighboring root exudates
Allelopathy involves the active synthesis and release of biochemical compounds into the surrounding environment. Recognized release mechanisms include leaf leaching, gaseous volatilization from foliage, root exudation into the soil, and residue decomposition. Conversely, absorbing compounds released by neighboring roots is an uptake process of the receiving plant rather than a release pathway of the donor.

82. (C) Small-seeded annuals and shallow perennials
Shifting from deep moldboard plowing to shallow cultivation alters the distribution of weed seeds and propagules. Deeply buried seeds remain dormant, while seeds near the soil surface receive environmental cues to germinate. This management shift favors small-seeded annuals that germinate from shallow depths, alongside shallow-rooted perennials that propagate from undisturbed rhizomes and stolons.

83. (B) Translocate through the vascular system to meristems
Glyphosate is a systemic herbicide, meaning it must be absorbed by the foliage and translocated throughout the plant's vascular system. It moves primarily through the phloem along with photoassimilates, traveling from source leaves to active metabolic sinks, such as root and shoot meristems. This movement ensures the chemical reaches and destroys growing tissues.

84. (D) It is dry granules that break apart and suspend in water.
Water Dispersible Granules are dry, granular herbicide formulations designed to be mixed with water prior to application. When added to the spray tank, these granules quickly break apart and disperse uniformly, forming a stable suspension of active ingredient particles in water. This formulation minimizes inhalation dust hazards while maintaining excellent ease of handling.

85. (B) I and III
Photosystem II inhibitor herbicides, such as triazines and ureas, target the photosynthetic pathway of susceptible plants. These compounds bind directly to the QB-binding niche of the D1 protein in the chloroplast thylakoid membrane, blocking electron transport. This blockage stops carbon dioxide fixation and causes a buildup of toxic reactive oxygen species, leading to leaf chlorosis and necrosis.

86. (C) Stress-induced reduction in absorption and translocation
Severe drought stress compromises the efficacy of foliar-applied systemic herbicides. Under water-limiting conditions, plants develop thicker cuticular wax layers that restrict chemical absorption. Additionally, drought drastically slows down internal vascular translocation and photosynthetic activity, preventing the absorbed herbicide from reaching active meristematic target sites, which ultimately results in poor weed control.

87. (A) Different chemical families with distinct modes of action
Multiple herbicide resistance is confirmed when a weed population survives recommended field rates of different chemical families with completely distinct modes of action. This condition arises from the accumulation of multiple resistance mechanisms, such as combining target-site mutations with enhanced metabolic pathways. It represents a more complex management challenge than single-site cross-resistance.

88. (D) Volatilization into the atmosphere
Highly volatile herbicides possess high vapor pressure, making them susceptible to phase change from liquid to gas. Applying these chemicals on hot, dry soil without immediate mechanical incorporation triggers rapid volatilization. The chemical molecules convert into gaseous vapors and escape into the atmosphere, which significantly reduces soil concentrations and compromises weed control efficacy.

89. (B) Conjugation
Conjugation is a key phase in the metabolic pathway of herbicide detoxification inside plant tissues. During this biochemical process, specific enzymes, such as glucosyltransferases or glutathione S-transferases, attach endogenous molecules like glucose or glutathione to the herbicide structure. This attachment renders the chemical compound hydrophilic, non-toxic, and ready for vacuolar storage.

90. (C) Increasing the application pressure significantly
Mitigating herbicide spray drift requires managing droplet size and physical application parameters. Lowering boom height and using drift-reduction nozzles produce larger, heavier droplets that resist wind movement. Conversely, significantly increasing application pressure shears the liquid into extremely fine droplets. These small droplets remain suspended in air currents, increasing the risk of off-target drift.

91. (D) They typically possess a broad host range, attacking multiple crops alongside weeds.
Phytopathogens utilized in biological weed control are selected for high virulence and strict host specificity. This ensures they selectively infect and suppress the target weed without harming crops or non-target native vegetation. A broad host range is a highly undesirable trait, as it poses unacceptable ecological and economic risks to nearby cultivated agricultural systems.

92. (A) Spore desiccation and failure to infect
Folia-applied mycoherbicides rely on viable fungal spores to infect target weeds. Spore germination and subsequent host cuticle penetration require a period of free moisture or high relative humidity. Under dry conditions without dew, the fungal spores suffer rapid desiccation and death, preventing infection and significantly reducing the overall bioherbicide efficacy.

93. (B) Mechanical control
Using a rotary hoe to physically uproot weed seedlings during their white thread stage is a classic mechanical control method. This physical action disrupts weed growth before root systems establish. Uprooted seedlings are exposed to the sun and rapidly desiccate. Relying on physical soil disturbance is an effective non-chemical weed management strategy.

94. (B) Mustard
Orobanche is an obligate root parasite that infests broadleaf crops, particularly brassicaceous crops like mustard and rapeseed, solanaceous species, and some legumes. The parasite lacks chlorophyll and extracts moisture and nutrients by connecting directly to host roots. This

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physiological parasitism causes severe crop stunting, chlorosis, and dramatic yield losses in heavily infested fields.

95. (D) III only
Emergent aquatic weeds are rooted in the bottom sediment, but their stems and leaves extend above the water surface. Classic examples include Typha and Phragmites, which typically occupy shallow marginal waters. Because they are rooted, these weeds extract nutrients primarily from the bottom sediment rather than drawing them directly from the surrounding water columns.

96. (C) Weed growth stage and crop tolerance window
The timing of post-emergence herbicide applications is physiologically determined by the weed growth stage and the crop tolerance window. Applying chemical treatments when weeds are small and actively growing maximizes absorption and efficacy. Simultaneously, the application must align with the crop's developmental window to prevent chemical injury, ensuring selective and effective weed control.

97. (D) Combining a stale seedbed technique with early mechanical inter-row cultivation
Short-duration vegetable crops benefit from an integrated weed management strategy that minimizes chemical residues and soil disturbance. Combining the stale seedbed technique with early mechanical inter-row cultivation is highly effective. This approach stimulates initial weed flush for removal before planting, followed by targeted mechanical cultivation between crop rows to suppress subsequent weed flushes.

98. (C) Gene flow (introgression)
Gene flow describes the physical transfer of genetic material from genetically modified crops to sexually compatible wild relatives. This transfer occurs via pollen dispersal and subsequent hybridization. If the crop possesses transgene traits like herbicide tolerance, backcrossing can integrate the resistance gene into wild populations, creating highly competitive weeds that resist traditional chemical control methods.

99. (B) Uniform broadcast application across the field
Site-specific weed management utilizes precision technology to detect weed patches and apply herbicides only where needed. Implementing uniform broadcast applications across the entire field completely negates these technological benefits. Broadcast spraying treats infested and weed-free zones identically, increasing overall chemical use, operational costs, and environmental impacts while defeating the core goals of precision agriculture.

100. (D) Cost-Benefit Ratio and Net Returns of each treatment
Choosing between manual weeding and chemical herbicide programs requires a detailed economic comparison. This evaluation is performed by calculating the cost-benefit ratio and net returns for each treatment option. These economic metrics quantify the financial returns generated per unit cost, allowing growers to select the most profitable, resource-efficient, and sustainable weed management strategy.

101. (A) Genetic or physiological traits of the seed
Innate or primary dormancy is a natural physiological state of seed arrest present at the time of dispersal from the parent plant. This dormancy type is directly controlled by genetic traits, internal hormone balances, or maternal tissues, such as impermeable seed coats. It acts as an evolutionary survival mechanism to prevent premature germination until optimal growth conditions are met.

102. (C) Pappus, hairs, or wings
Anemochory is the biological term for seed dispersal mediated by wind currents. This mechanism requires specific structural adaptations that reduce seed density and increase surface area. Common morphological features include lightweight plumes, pappus structures, fine hairs, or expanded wings. These aerodynamic structures capture air currents, allowing seeds to remain aloft and travel long distances.

103. (A) Is legally restricted due to its potential harm
Under international quarantine regulations, a noxious weed is distinguished primarily by its legal status rather than its botanical origin. These species are highly destructive and invasive, posing severe economic or ecological threats to agriculture and native flora. Consequently, regulatory bodies enact and enforce strict statutory laws that mandate their control, monitoring, and exclusion from trade channels.

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104. (D) Weeds extracting nutrients faster and in larger quantities
Crop-weed competition for soil nutrients is characterized by the superior resource-extraction capabilities of weeds. Weeds typically possess aggressive root growth, higher transpiration rates, and highly efficient physiological uptake mechanisms. These biological advantages allow them to extract vital nutrients, particularly nitrogen, faster and in much larger quantities than cultivated crops, leading to severe crop nutritional stress.

105. (A) II, III, I, IV
Calculating the Economic Threshold Level of a weed requires a logical step-by-step analytical sequence. First, the cost of the proposed weed control measure must be calculated. Next, the expected crop yield and its market price are estimated. Then, the proportional yield loss per weed is determined. Finally, these variables are solved to identify the threshold weed density.

106. (C) Their inhibitory concentration remains constant across all soil types.
Allelochemical activities are highly dependent on soil characteristics such as pH, texture, organic matter content, and microbial populations. These properties actively mediate the adsorption, degradation, and transport of allelopathic compounds. Consequently, the threshold concentration required to inhibit target plants varies significantly across different soil environments rather than remaining constant under all conditions.

107. (D) Be intercepted by the residue, requiring higher application rates or spray volumes to reach the soil
Conservation agriculture systems maintaining dense crop residue covers physically block sprayed pre-emergence herbicides from reaching the target soil surface. The organic residue acts as a physical barrier, trapping the chemical molecules on the surface. Farmers must use higher carrier volumes or increased application rates to facilitate wash-off into the active soil zone.

108. (A) During weed germination and subterranean emergence
Pre-emergence herbicides are strategically designed to target germinating weed seeds and young seedlings before they breach the soil surface. These chemical compounds are absorbed by emerging shoots or root systems during early developmental stages. This physiological timing disrupts cell division or metabolic pathways, terminating weed growth during subterranean development and preventing seedling establishment.

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109. (B) Application in standing water systems or soil incorporation without liquid drift
Granular herbicide formulations offer distinct physical advantages in specific agronomic scenarios, such as flooded rice paddies or wind-prone areas. These heavy particles sink through water columns to release the active ingredient directly at the soil-water interface. Additionally, because they are not sprayed as fine liquids, they completely eliminate the risk of atmospheric drift.

110. (B) Imidazolinones (IMIs)
Imidazolinones are a class of herbicides that specifically target the acetolactate synthase enzyme, which is critical for synthesizing branched-chain amino acids in plants. Conversely, aryloxyphenoxypropionates, cyclohexanediones, and phenylpyrazolins are chemically distinct groups that inhibit acetyl-CoA carboxylase, a key enzyme involved in fatty acid biosynthesis in susceptible monocotyledonous weed species.

111. (A) Biochemical metabolic selectivity
Maize exhibits natural tolerance to atrazine through internal physiological detoxification pathways. The crop possesses high endogenous levels of glutathione S-transferase enzymes, which catalyze the conjugation of the herbicide molecule with reduced glutathione. This enzymatic process rapidly converts the toxic parent compound into a non-toxic metabolite, representing a classic biochemical metabolic mechanism of selectivity.

112. (C) Accelerated enzymatic breakdown into non-toxic metabolites before reaching the target site
Enhanced metabolism resistance in weeds is a physiological mechanism where plants rapidly detoxify herbicide molecules. This non-target-site resistance typically involves upregulated enzyme systems, such as cytochrome P450 monooxygenases or glutathione S-transferases. These enzymes break down the active herbicide into harmless compounds, preventing the

chemical from reaching and binding to its intended physiological target site.

113. (D) The time required for soil herbicide concentration to degrade to 50% of its initial value
The half-life of an herbicide in soil represents a standardized quantitative measure of its environmental persistence. This parameter defines the duration necessary for biological, chemical, or photolytic processes to degrade exactly fifty percent of the originally applied active ingredient. It is a critical metric for predicting carryover injury risks to sensitive rotational crops.

114. (C) Phase I oxidation
In-plant herbicide metabolism generally proceeds through distinct phases to detoxify foreign chemical compounds. Phase I reactions introduce or expose reactive functional groups on the herbicide molecule through chemical processes like oxidation, reduction, or hydrolysis. Cytochrome P450 monooxygenases commonly catalyze these oxidation reactions, which serve as crucial preparatory steps for subsequent conjugation phases.

115. (D) A is false but R is true.
Flood jet nozzles operate at low pressures to generate very coarse droplets, which effectively minimizes physical spray drift. However, they are highly unsuitable for applying post-emergence systemic or contact herbicides because these applications require fine, uniform droplets to ensure thorough leaf coverage. Therefore, the assertion is incorrect while the supporting reasoning is factual.

116. (D) Phytophagous mites
The biological control agent Aceria chondrillae belongs to the family Eriophyidae, which comprises specialized plant-feeding microscopic organisms known as phytophagous mites. This specific mite acts as a highly host-specific herbivore on rush skeletonweed, causing gall formation that severely disrupts the weed's vascular system, reduces its reproductive capacity, and ultimately limits its spread in infested pastures.

117. (A) Mycelial fragments or resistant fungal spores
Commercial production of mycoherbicides utilizes large-scale industrial liquid fermentation technologies to culture specific fungal pathogens. This mass-culturing process is optimized to yield high concentrations of viable propagules, primarily consisting of stable fungal spores or vegetative mycelial fragments. These structures are harvested and formulated to remain viable during packaging, storage, and subsequent field application.

118. (C) It is a tactical tool integrated with other methods to manage populations and mitigate resistance.
Within an integrated weed management framework, chemical weed control is not utilized as a standalone eradication method. Instead, herbicides serve as targeted tactical tools combined with cultural, physical, and biological strategies. This diversified approach aims to suppress weed populations below economic thresholds while minimizing selection pressure to prevent the evolution of herbicide-resistant weed biotypes.

119. (A) It parasitizes the root systems of annual cereal crops.
Loranthus is a well-known aerial hemi-parasitic plant belonging to the Loranthaceae family. Unlike root parasites, it primarily infests the woody branches of perennial host trees, such as mango or citrus. It possesses green leaves and conducts its own photosynthesis, but relies on its host for water and minerals, with seeds dispersed widely by birds.

120. (D) Depressed dissolved oxygen and blocked sunlight, killing submerged flora and fauna
Dense mats of floating aquatic weeds like Salvinia molesta severely degrade aquatic ecosystems. By blanketing the water surface, they physically block sunlight penetration, preventing photosynthesis in submerged plants. The subsequent decay of massive weed biomass, combined with restricted atmospheric gas exchange, drastically depletes dissolved oxygen levels, causing widespread mortality among fish and other aquatic organisms.

121. (B) 15 to 45 days after sowing
The critical period of weed control in major oilseed crops like groundnut and soybean typically occurs between fifteen and forty-five days after sowing. During this early developmental phase, slow initial crop growth and open canopies make them highly vulnerable to weed competition.

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Ensuring weed-free conditions during this window is essential to prevent significant yield losses.

122. (C) Their slow early growth and wide row spacing, leaving unshaded soil
High-value vegetable crops generally exhibit slow early growth rates and are planted with wide spacing between rows. This structural arrangement leaves a significant portion of the soil surface unshaded and exposed to direct solar radiation. Consequently, opportunistic weeds germinate rapidly and outcompete the vulnerable young vegetable seedlings unless rigorous weed management is maintained.

123. (D) The crop metabolizes glyphosate into AMPA to prevent toxicity.
Roundup Ready crops are genetically engineered to survive glyphosate applications by expressing a transgene encoding the CP4 EPSPS enzyme. This modified bacterial enzyme is structurally immune to glyphosate inhibition, allowing the plant to synthesize essential aromatic amino acids. Metabolic degradation of glyphosate into aminomethylphosphonic acid is not the physiological mechanism of tolerance in these transgenic crop varieties.

124. (A) Creating spatial maps of weed patches for variable rate herbicide application
Drone-based weed mapping utilizes high-resolution multispectral or RGB sensors to capture spatial data across agricultural fields. Advanced software processes these aerial images to distinguish crop rows from weed infestations. The resulting localized maps are integrated into variable-rate technology systems, enabling sprayers to target herbicide applications precisely to weed patches, reducing chemical use.

125. (B) P-2, Q-1, R-3, S-4
Evaluation of weed control efficacy relies on specific mathematical formulations. Weed control efficiency based on biomass compares dry weed weights between treated and control plots. The weed index quantifies relative yield loss due to competition. The herbicide efficiency index integrates both weed-killing capacity and crop safety, while the density-based index compares weed populations directly.

126. (B) Fragment tuber chains, spreading and propagating the weed
Cyperus rotundus is a highly persistent perennial weed that propagates primarily via underground tuber networks. Conducting mechanical tillage under moist soil conditions breaks these interconnected tuber chains into smaller individual segments. Rather than eradicating the weed, this fragmentation breaks apical dominance, stimulating dormant buds on separate tubers to sprout and rapidly expand the infestation.

127. (A) Anemochory
The dispersal of dandelion seeds over vast distances is facilitated by a specialized feathery structure known as a pappus. This aerodynamic modification acts like a parachute, reducing the falling velocity of the seed and allowing ambient wind currents to carry it far from the parent plant. This wind-driven dispersal mechanism is scientifically classified as anemochory.

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128. (C) Monocotyledonous weeds (Narrow-leaved)
Weeds belonging to the Poaceae and Cyperaceae families possess embryos with a single cotyledon upon germination. Morphologically, these plants are characterized by narrow, elongated leaves with parallel venation and fibrous root systems. Based on cotyledon classification, they are categorized as monocotyledonous weeds, commonly referred to as narrow-leaved weeds or grasses and sedges.

129. (D) The early-emerging plant captures resources, gaining a major advantage.
Crop-weed competition is described as asymmetrical because slight differences in the timing of emergence generate disproportionate competitive advantages. The individual that germinates first occupies physical space, establishes a deeper root system, and develops a larger leaf canopy. This early resource capture allows it to shade and suppress later-emerging individuals, compounding its competitive dominance over time.

130. (C) Implement control measures, as density exceeds the threshold
The economic threshold level represents the specific pest density at which the cost of implementing control measures is exactly equal to the value of the crop yield saved. When field scouting reveals a weed density of twelve plants

per square meter, which exceeds the threshold of five, immediate management intervention is economically justified to prevent net financial loss.

131. (B) Immediate conversion of the allelochemical into a synthetic herbicide
Soil environments heavily influence the persistence and biological activity of exuded allelochemicals. Physical adsorption to clay minerals, microbial degradation, and leaching through the soil profile are all recognized pathways that alter their concentration in the root zone. However, soil organisms and physical processes cannot synthesize or transform these organic compounds into commercial synthetic herbicides.

132. (D) It disrupts the life cycle of weeds adapted to mono-cropping, reducing their dominance.
Continuous mono-cropping selects for specific weed species whose life cycles, germination periods, and growth habits align perfectly with the crop. Introducing a diverse crop rotation alters the timing of planting, soil disturbance, tillage, and herbicide use. This ecological variation disrupts the reproductive cycles of specialist weeds, preventing any single species from establishing absolute dominance.

133. (A) After both the crop and weeds have emerged
A post-emergence herbicide application refers specifically to the timing of chemical treatment in the field. This agronomic practice requires that the herbicide be applied directly to the foliage of weeds and crops after they have successfully germinated and breached the soil surface, targeting active vegetative growth rather than dormant seeds or underground structures.

134. (C) Reduce water surface tension, helping droplets spread on waxy leaves
Surfactants are critical adjuvants added to spray mixtures to modify the physical properties of the carrier liquid. By significantly reducing the surface tension of water, these compounds prevent spray droplets from bouncing off hydrophobic, waxy leaf cuticles. This allows the liquid to spread evenly across the leaf surface, enhancing chemical contact and subsequent cellular absorption.

135. (A) I, II and V
Glyphosate is the primary commercially significant EPSPS inhibitor. It operates as a non-selective, highly systemic post-emergence herbicide that translocates throughout plant tissues, blocking the shikic acid pathway and preventing aromatic amino acid synthesis. Because it is non-selective, it is not inherently safe for conventional, non-genetically modified crop varieties, making statements I, II, and V correct.

136. (D) Wheat has narrow, upright, waxy leaves that repel droplets, while broadleaves intercept them.
The selective action of 2,4-D in cereal crops like wheat is heavily influenced by morphological differences between monocots and dicots. Wheat plants possess narrow, vertically oriented leaves coated with a thick waxy cuticle, causing spray droplets to bounce off. Conversely, broadleaf weeds exhibit wide, horizontal leaves that capture and retain a greater volume of the herbicide.

137. (B) Rotate to an alternative herbicide with a completely different mode of action
When a weed population develops target-site resistance to a specific class of herbicides, such as ALS inhibitors, continuing to use that chemical group becomes completely ineffective. To suppress the resistant biotypes and prevent further selection pressure, growers must immediately rotate to an alternative herbicide possessing an entirely different biochemical site and mode of action.

138. (C) Adsorption
The retention of herbicide molecules on the surfaces of soil mineral clays and organic matter fractions is defined as adsorption. This physical and chemical binding process is driven by electrostatic attractions and van der Waals forces. Adsorption directly influences herbicide bioavailability, as bound molecules are temporarily restricted from plant uptake, leaching, and microbial degradation.

139. (D) It occurs most rapidly in completely sterile, highly acidic, and desiccated soils.
Microbial degradation is the primary pathway for breaking down most organic herbicides in agricultural soils. This biological process relies on active populations of soil bacteria and fungi, which require favorable moisture, warm temperatures, neutral pH, and adequate aeration

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to thrive. Consequently, degradation is severely restricted, rather than accelerated, in sterile, acidic, or extremely dry soils.

140. (A) Tractor-mounted boom sprayer
Tractor-mounted boom sprayers are the industry standard for broad-acre herbicide applications in mechanized cereal farming. These systems feature wide, horizontal booms fitted with multiple evenly spaced nozzles, allowing rapid and highly uniform coverage across expansive fields. They are designed to operate efficiently under precise pressure controls, maximizing field productivity while minimizing labor requirements.

141. (B) It is highly effective for rapidly eradicating weeds in intensive, short-duration vegetable cropping systems.
Classical biological weed control is characterized by a slow, long-term suppression of target weed populations. It relies on the gradual establishment and cycling of imported natural enemies. This slow mechanism makes it highly unsuitable for short-duration, high-intensity vegetable cropping systems, where weeds must be suppressed immediately within weeks to prevent severe crop losses.

142. (B) A requirement for prolonged leaf wetness to allow spore germination
The efficacy of mycoherbicides in the field is frequently constrained by microclimatic conditions, particularly relative humidity. Fungal spores require a continuous period of free moisture or high humidity on the leaf surface to germinate, form appressoria, and penetrate the host cuticle. Dry field conditions during application lead to spore desiccation and subsequent control failure.

143. (A) Delayed evolution of herbicide resistance and long-term weed suppression
Implementing integrated weed management programs combining diverse cultural, physical, and chemical strategies suppresses weed populations effectively. By varying the control mechanisms, the system avoids relying on a single chemical tool. This diversification minimizes the directional selection pressure for specific resistant biotypes, successfully delaying the evolution of herbicide resistance across the farm.

144. (C) Haustorium
Parasitic weeds, such as Striga and Cuscuta, develop a specialized physiological bridge to connect with their hosts. This specialized vegetative organ, known as a haustorium, penetrates the host plant's vascular system. Once established, the haustorium actively diverts water, inorganic nutrients, and organic assimilates from the host to fuel the growth and reproduction of the parasite.

145. (D) II only
Managing problematic perennial weeds in non-cropped areas requires targeting their underground vegetative structures. Systemic, non-selective herbicides are highly effective because they translocate through the phloem down into roots, rhizomes, or tubers, causing complete destruction. Conversely, physical methods like mowing or shallow tillage often fail because they leave viable underground reproductive tissues intact.

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146. (C) 2.0 kg
To apply one kilogram of active ingredient per hectare using a wettable powder formulation containing fifty percent active ingredient, a simple dilution calculation is performed. The required commercial product weight is calculated by dividing the target active ingredient rate by the active fraction of the formulation, which yields exactly two kilograms of formulated product.

147. (B) Maintaining cover crops in inter-rows while treating under-canopy zones with directed herbicides
Sustainable weed management in mature orchards avoids intensive tillage, which can damage shallow tree roots. The most effective strategy involves maintaining low-growing cover crops in the inter-row spaces to prevent soil erosion and suppress weeds. Directed applications of contact or systemic herbicides are restricted to the under-canopy zones immediately surrounding the tree bases.

148. (D) Soil bacteria (Streptomyces spp.)
The pat and bar genes, which confer transgenic tolerance to glufosinate ammonium in Liberty Link crops, code for the enzyme phosphinothricin acetyltransferase. These specific genes were originally isolated from soil-dwelling actinomycete bacteria belonging to the genus Streptomyces, specifically Streptomyces viridochromogenes and

Streptomyces hygroscopicus, which naturally produce the herbicidal compound bialaphos.

149. (A) Sub-soiling tines for immediate deep incorporation of the chemical
Drone-based precision herbicide application systems utilize aerial platforms equipped with GPS, multi-spectral sensors, and specialized spray nozzles to map and treat weed patches. These systems are designed strictly for aerial operations and do not feature heavy mechanical ground-engaging implements, such as sub-soiling tines, which require tractor power for deep soil incorporation.

150. (C) +$60/ha
Using partial budgeting, the net change in profit is determined by subtracting the total financial losses from the total financial gains. The gains consist of added returns and reduced costs, totaling one hundred and ten dollars. The losses comprise added costs and reduced returns, totaling fifty dollars. This calculation yields a positive net change of sixty dollars.

151. (A) It is an irreversible condition that permanently prevents germination.
Physical seed dormancy caused by a thick, impermeable seed coat is a temporary physiological mechanism that prevents premature germination. This condition is reversible in nature. Environmental factors such as temperature fluctuations, microbial action, animal digestion, or mechanical scarification eventually break down the seed coat, allowing water and oxygen uptake to initiate the germination process.

152. (D) Cleaning farm machinery before moving between fields
The transport of weed seeds in mud adhering to agricultural machinery is a major pathway for weed dispersal across farms. This physical movement facilitates the introduction of problematic weed species into previously uninfested fields. Consequently, thoroughly cleaning tractors and tillage implements before moving between fields is a critical preventive sanitation practice.

153. (B) Ecology and soil-type classification
Weeds that are specifically adapted to thrive under particular soil and environmental conditions, such as acidic waterlogged fields, are classified based on their ecological preferences. This classification system groups weeds according to their affinity for specific soil pH ranges, moisture regimes, salinity levels, or climatic zones, reflecting their specialized physiological adaptations.

154. (C) The crop-weed density ratio and duration of coexistence
In crop-weed ecology, the competitive threshold or damage boundary is defined as the weed density at which measurable crop yield loss first occurs. This boundary is primarily determined by evaluating the crop-to-weed density ratio and the duration of their coexistence, as higher weed populations and longer periods of competition increase resource depletion.

155. (C) A is true but R is false.
The weed index is a standard agronomic metric used to calculate the percentage yield reduction caused by weed competition compared to a completely weed-free control plot. Therefore, a higher weed index value indicates greater yield loss and poorer weed management efficiency in the treated plot, making the assertion true while the supporting reasoning is false.

156. (A) Severe allelopathic inhibition of small-seeded broadleaf weeds
Sorgoleone is a highly potent hydrophobic benzoquinone exuded continuously by the root hairs of Sorghum bicolor. This compound serves as a natural bio-herbicide, disrupting electron transport in photosystem II and mitochondrial respiration of neighboring plants. Its active exudation causes severe allelopathic inhibition of germinating weeds, particularly small-seeded broadleaf species in the rhizosphere.

157. (B) A stable weed community adapted to a long-term agronomic practice
In weed ecology, the term weed flora climax refers to a stable, persistent association of weed species that has reached equilibrium under a continuous, long-term system of agricultural management. When crop rotations, tillage regimes, and herbicide programs remain constant for multiple years, they select for a highly adapted, predictable community of dominant weeds.

158. (B) Glyphosate - Sulfonylurea
To ensure proper herbicide rotation and management, chemical compounds are classified

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into specific families based on their structures. Atrazine belongs to the triazines, pendimethalin to the dinitroanilines, and 2,4-D to the phenoxycarboxylic acids. However, glyphosate is an organophosphorus compound belonging to the glycine chemical family, not the sulfonylurea group, which comprises ALS inhibitors.

159. (A) Finely ground solid particles forming a water suspension that requires continuous tank agitation
Wettable powders are dry, finely ground herbicide formulations containing active ingredients blended with inert carriers and dispersing agents. When mixed with water in a spray tank, these insoluble particles do not dissolve but form a physical suspension. To prevent the heavy particles from settling to the bottom, continuous mechanical or hydraulic tank agitation is required.

160. (C) Abnormal cell division and elongation, causing severe epinasty and twisted growth
Synthetic auxin herbicides, such as 2,4-D, mimic natural plant growth hormones but are highly stable and persistent in susceptible dicots. Their application triggers uncontrolled, rapid cell division and elongation in vascular tissues. This abnormal physiological growth leads to characteristic malformations, including severe twisting of stems, epinasty of leaves, and ultimate vascular system collapse.

161. (D) Positional depth-based selectivity
Positional or depth-based selectivity exploits the spatial separation between the applied herbicide and the crop seed. Placing a soil-active herbicide on the soil surface while planting the crop seed deeply in untreated soil zones ensures that the crop roots develop below the chemical layer. This prevents crop exposure while controlling shallow-germinating weed seeds.

162. (C) Target-site gene amplification
Target-site gene amplification is a molecular mechanism of herbicide resistance where the weed genome replicates the gene encoding the target enzyme multiple times. This genomic duplication results in the massive overproduction of the target enzyme within the plant cells. The abundance of enzymes outcompetes the applied herbicide, allowing normal metabolic pathways to proceed unimpeded.

163. (B) Runoff
The lateral movement of dissolved herbicide molecules or soil-bound chemical particles across the ground surface is defined as runoff. This process is typically driven by intense precipitation or excessive irrigation events that exceed the soil's infiltration capacity. Runoff can transport herbicides away from the target field, potentially contaminating adjacent water bodies or non-target vegetation.

164. (D) Photolytic fragmentation of the carbon skeleton via chloroplast UV emission
In-plant herbicide detoxification occurs through three recognized physiological phases: Phase I modifications, Phase II conjugation with endogenous compounds, and Phase III sequestration into vacuoles or cell walls. Chloroplasts do not emit ultraviolet radiation to cause photolytic fragmentation of herbicide carbon skeletons, making this process an unrecognized pathway in plant metabolic systems.

165. (B) P-3, Q-4, R-1, S-2
Sprayer efficiency relies on the correct function of its components. The pump generates the pressure and flow required to move liquid. The agitator maintains uniform suspension of wettable powders. The pressure regulator controls and stabilizes application pressure across the boom. Finally, the nozzle atomizes the liquid, determining both droplet size and the physical spray pattern.

166. (C) Lacking any natural predators or parasitoids in the introduced environment
The successful establishment and rapid population growth of a biological control agent in a new region is heavily favored when it experiences enemy release. In the introduced environment, the agent is freed from the suppressive pressures of its co-evolved specialized predators, pathogens, and parasitoids, allowing it to multiply rapidly and exert intense feeding pressure on the target weed.

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167. (A) Spore desiccation, causing failure to germinate and penetrate the cuticle
The field efficacy of mycoherbicides is highly sensitive to ambient environmental conditions. Applying these living fungal formulations during hot, dry afternoons exposes the vulnerable spores to high temperatures and low relative

humidity. This microclimate induces rapid spore desiccation, preventing successful germination and the subsequent formation of infection structures required to penetrate the host cuticle.

168. (D) Deplete the surface seed bank without disturbing deeper seeds
The stale seedbed technique is a cultural weed management practice that involves preparing a seedbed and allowing weeds to germinate. These emerged seedlings are subsequently destroyed using shallow thermal or chemical methods before crop sowing. This strategy aims to deplete the germinable weed seed bank near the soil surface without bringing deeper dormant seeds upward.

169. (B) Root system
Striga species are obligate root parasitic weeds that present severe challenges in cereal production. The seeds of this parasite remain dormant in the soil until stimulated by chemical exudates from host roots. Upon germination, the parasite develops a haustorium that attaches directly to the host's root system, withdrawing water, minerals, and carbon compounds.

170. (C) Mechanical cutting provides permanent eradication of perennial aquatic weeds like Hydrilla.
Mechanical harvesting and dredging are valuable techniques for physically removing massive aquatic weed biomass. However, mechanical cutting does not provide permanent eradication of perennial species like Hydrilla. Cutting often leaves underground tubers intact and generates viable plant fragments that disperse with water currents, potentially initiating new infestations and accelerating the spread of the weed.

171. (D) After sowing the crop but before the emergence of crop and weed seedlings
The application window for a pre-emergence herbicide is precisely defined within crop production. It must be applied to the soil surface after the crop has been sown but before both the crop seeds and weed seeds germinate and breach the soil surface. This timing targets germinating weeds at their most vulnerable early physiological stages.

172. (A) They actively and permanently sterilize the soil microbiome.
Organic mulches suppress weeds by physically blocking sunlight, reducing soil temperature fluctuations, and retaining soil moisture. Upon decomposition, they also enrich the soil with organic matter. They do not actively or permanently sterilize the soil microbiome; instead, they generally support beneficial microbial activity by maintaining a favorable and stable soil microclimate.

173. (B) HT gene transfer into wild species via pollen-mediated gene flow
Cultivating herbicide-tolerant crops adjacent to wild, sexually compatible relatives presents a high risk of gene flow. Wind or insect pollinators can transfer the transgenic herbicide-tolerance genes to the wild species through cross-pollination. This hybridization can lead to the evolution of herbicide-resistant wild biotypes, creating persistent weed management challenges in agricultural ecosystems.

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174. (B) Variable Rate Technology (VRT)
Precision agricultural systems integrate spatial mapping with advanced delivery hardware. When a sprayer utilizes drone-generated weed maps to dynamically adjust herbicide doses in real-time based on local weed density as it traverses the field, it is employing variable rate technology. This targeted approach optimizes chemical efficacy while significantly reducing overall herbicide inputs.

175. (D) Calculate Total Cost of Cultivation → Calculate Gross Returns from Yield → Divide Gross Returns by Total Cost
Conducting a cost-benefit ratio analysis of an agricultural practice requires a structured sequence. The economist first determines the total cost of cultivation, including all input and operational expenses. Next, the gross returns are calculated based on crop yield and market price. Finally, the gross returns are divided by the total cost to determine the ratio.

176. (C) Located at or very near the soil surface
Many small-seeded weed species possess light-sensitive seeds that exhibit photodormancy. The requirement for red light exposure, which is sensed by phytochrome pigments, serves as an evolutionary adaptation. This mechanism ensures that these seeds initiate germination

only when they are located at or very near the soil surface, where seedlings can successfully reach light before depleting resources.

177. (D) Hydrochory
Irrigation canals act as highly efficient continuous pathways for the passive transport of weed seeds across agricultural regions. Seeds, vegetative propagules, and entire floating weeds are carried downstream by moving water, depositing them directly into cultivated fields. This water-mediated dispersal mechanism is defined as hydrochory and is a major vector for spreading noxious weeds.

178. (C) Arable, aquatic, and ruderal weeds
The ecological classification of weeds groups species based on their primary habitats and environmental preferences. This system categorizes weeds into groups such as arable weeds, which infest cultivated agricultural fields; aquatic weeds, which thrive in water bodies; and ruderal weeds, which colonize disturbed non-cropped areas like roadsides, waste grounds, and industrial sites.

179. (B) Combined effects of resource competition and chemical allelopathy
In weed science, the comprehensive term interference describes the overall negative impact that neighboring plants exert on each other. It encompasses both physical competition for limited essential resources, such as water, nutrients, and sunlight, and chemical allelopathy, where plants release phytotoxic compounds into the environment to actively suppress the growth of surrounding vegetation.

180. (D) The Damage Boundary fluctuates with crop market prices, while ETL is biologically fixed.
The damage boundary is a biologically determined weed density where crop yield loss first becomes statistically measurable, remaining independent of economic fluctuations. Conversely, the economic threshold level is a dynamic economic index. It fluctuates continuously with changes in crop market prices, herbicide costs, and application expenses rather than being biologically fixed.

181. (A) Arid environments with high temperatures
The release and dissemination of volatile allelochemicals, such as gaseous terpenes, rely heavily on atmospheric conditions. High temperatures and dry climates facilitate the rapid volatilization of these compounds from plant leaves and stems into the surrounding air. Consequently, this mechanism of allelopathic inhibition is most pronounced and ecologically significant in arid and semi-arid environments.

182. (C) Wind-dispersed annuals and simple perennials like dandelions
Shifting from conventional tillage to minimum or zero tillage reduces soil inversion, leaving the soil surface relatively undisturbed. This shift favors weed species whose seeds accumulate and germinate near the surface. Consequently, wind-dispersed annuals and simple perennial weeds with wind-borne seeds, such as dandelions, typically increase in dominance because their reproductive cycles are undisturbed by plowing.

183. (A) Rapid production of free radicals, destroying cell membranes and causing foliar desiccation
Paraquat and other bipyridylium herbicides act by diverting electrons from photosystem I in the presence of light. This process generates highly reactive oxygen species and free radicals within chloroplasts. These radicals rapidly attack and lipid-peroxidize cell membranes, leading to rapid cell leakage, localized tissue collapse, and rapid foliar desiccation within hours of application.

184. (D) Separate into distinct oil and solvent layers, causing uneven application
Emulsifiable concentrates are formulated by dissolving hydrophobic active ingredients in organic solvents along with emulsifying agents. When mixed with water, the emulsifiers stabilize the oil droplets in a uniform emulsion. If these emulsifiers degrade during storage, the formulation loses its physical stability, separating into distinct oil and solvent layers, leading to highly uneven chemical application.

185. (B) II only
HPPD inhibitors block the enzyme hydroxyphenylpyruvate dioxygenase, disrupting plastoquinone synthesis and destroying protective carotenoid pigments. This results in severe bleaching of new plant growth, making them highly selective tools for broadleaf weed control in maize. They do not induce rapid cell division or auxin-like epinasty in grasses, making statement II incorrect.

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186. (C) Mature weeds with thick cuticles are less sensitive than young, active seedlings.
Physiological age-based selectivity refers to differences in herbicide sensitivity as plants progress through growth stages. Young, actively growing weed seedlings have thin, permeable cuticles and high metabolic activity, facilitating rapid herbicide absorption. Conversely, mature weeds develop thick, waxy cuticles and slower metabolic rates, making them significantly less sensitive to identical chemical application rates.

187. (D) Continuously utilizing a single, highly effective herbicide at lower-than-recommended doses prevents resistance from developing.
Effectively managing herbicide resistance requires diversifying weed control tactics. Recommended strategies include rotating herbicide modes of action, tank-mixing chemicals with different target sites, and integrating cultural methods. Repeatedly applying a single herbicide at sub-lethal, lower-than-recommended doses actually accelerates resistance development by selecting for individuals with quantitative, metabolic resistance mechanisms.

188. (A) Higher rates, because more active ingredient is adsorbed and unavailable for weed uptake
Soils characterized by high cation exchange capacity and abundant organic matter possess numerous negatively charged binding sites. These sites physically adsorb soil-applied pre-emergence herbicides, reducing the concentration of active molecules dissolved in soil water. To overcome this high adsorption capacity and maintain effective weed control, higher chemical application rates must be utilized.

189. (B) Microbial degradation where the microbe derives no energy or carbon from the herbicide
Co-metabolism is a specific microbial degradation pathway where microorganisms transform an herbicide molecule while utilizing another primary substrate as their source of carbon and energy. The microbe derives no nutritional or energetic benefit directly from breaking down the herbicide. This process is highly dependent on the presence of alternative organic substrates in the soil.

190. (B) Tapered flat fan
Achieving a highly uniform broadcast application of herbicides across a bare soil surface requires precise nozzle selection. Tapered flat fan nozzles produce a flat, fan-shaped spray pattern with decreasing volume at the outer edges. Spacing these nozzles evenly along a spray boom allows adjacent spray patterns to overlap, resulting in uniform chemical distribution.

191. (A) Biological restriction to feeding and reproducing only on the target weed
Host specificity is the fundamental safety criterion in biological weed control programs. This biological parameter refers to the strict restriction of an introduced insect or pathogen to feeding, developing, and reproducing solely on the target weed species. This specificity ensures that the biological agent will not feed on or damage non-target native vegetation or cultivated crops.

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192. (C) Broad-spectrum activity capable of killing multiple weed families simultaneously
The commercialization of bio-herbicides is constrained by several biological and economic factors, including high production costs, short product shelf-life, and strict environmental requirements for field efficacy. However, possessing a broad-spectrum activity is not a typical limitation of these agents; rather, most bio-herbicides are highly host-specific, which restricts their utility in diverse weed communities.

193. (D) Maintaining optimum to slightly higher crop plant populations promotes rapid canopy closure, which efficiently suppresses late-emerging weeds.
Crop density is a highly effective cultural weed management tool. Establishing optimum to slightly elevated crop plant populations promotes rapid development of the foliar canopy. This early canopy closure shades the soil surface, blocking sunlight penetration and thereby suppressing the germination and growth of late-emerging weeds without requiring additional chemical or mechanical intervention.

194. (C) Exude stimulants inducing suicidal germination of parasite seeds without hosting them
Trap crops are utilized in managing root parasitic weeds like Striga through a biological mechanism. These crops exude natural chemical stimulants into the rhizosphere that trigger the germination of dormant parasite seeds. However, because the trap crops are non-hosts, the germinated parasite seedlings cannot successfully attach to their roots and subsequently die of starvation.

195. (B) I, II and IV
Successful biological control of aquatic weeds is exemplified by using Neochetina weevils to manage water hyacinth and introducing herbivorous grass carp for submerged weeds. Aquatic habitats offer stable microclimates that support agent establishment. However, agents require strict host-specificity testing before release, and control is gradual rather than instantaneous, making statements I, II, and IV correct.

196. (D) Broaden the spectrum of weed species controlled in a single pass
Preparing tank mixtures of compatible herbicides with different chemical profiles is a common agronomic practice. The primary biological objective of combining two distinct active ingredients is to broaden the spectrum of weed species controlled during a single field application, as one chemical may target broadleaf weeds while the other selectively controls annual grass species.

197. (A) Herbigation by injecting herbicides directly through the drip irrigation system
In drip-irrigated orchard crops, weed growth is heavily concentrated in wet zones directly beneath the emitters. Applying herbicides through herbigation is a highly efficient, targeted management strategy. By injecting soluble herbicides directly into the drip irrigation water, the chemical is delivered precisely to the wet zones where weeds germinate, minimizing overall chemical inputs.

198. (C) They cannot be controlled by the specific herbicide to which they were engineered to be tolerant, necessitating an alternate mode of action.
Volunteer crops emerging from seed losses of the previous season's herbicide-tolerant crop present unique weed management challenges. Because these volunteers carry the transgenic trait, they survive applications of the primary herbicide to which they were engineered. Controlling these plants in the subsequent crop requires farmers to utilize alternative herbicides possessing completely different modes of action.

199. (A) Detect, classify, and map distinct weed species in real-time within crop canopies
Advanced machine vision systems in precision agriculture utilize deep learning convolutional neural networks to process live video feeds from cameras. These networks are trained to detect, classify, and map distinct weed species in real-time within active crop canopies. This spatial data enables smart sprayers to apply herbicides selectively to targeted weeds, reducing waste.

200. (C) Often ignores long-term unquantified ecological benefits, focusing solely on immediate monetary returns
A key limitation of relying exclusively on the cost-benefit ratio to evaluate integrated weed management strategies is its narrow economic focus. This metric calculates direct, short-term monetary inputs and immediate yield outputs. Consequently, it often overlooks long-term, unquantifiable ecological advantages, such as reduced herbicide resistance risks, improved soil health, and minimized environmental contamination.

201. (B) After-ripening, allowing internal chemical inhibitors to dissipate during dry storage
Innate physiological dormancy in many temperate weed seeds is broken through after-ripening. This developmental process occurs while the seed is in dry storage or during dry field conditions after shedding. Over time, internal chemical germination inhibitors, such as abscisic acid, gradually dissipate or undergo metabolic breakdown, allowing the embryo to respond to germination cues.

202. (A) Both A and R are true and R is the correct explanation of A.
Weed seeds possessing specialized appendages, such as a pappus or wings, demonstrate high dispersal efficiency. These aerodynamic modifications increase the physical surface area and aerodynamic drag of the seed relative to its weight. This allows ambient wind currents to carry the seed over vast distances, validating the assertion and confirming the supporting reason.

203. (D) Divert resources into growth and reproduction due to the absence of co-evolved herbivores
The enemy release hypothesis explains why invasive alien weeds like Lantana camara proliferate rapidly in new geographic regions. Upon escaping their native habitats, these species are freed from their co-evolved specialized herbivores and pathogens. This absence of natural enemies allows the weeds to redirect resources from chemical defense mechanisms

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into rapid vegetative growth and reproductive output.

204. (A) Critical time of weed removal
Determining the critical period of weed control requires modeling two distinct crop yield loss curves as functions of time. The first curve defines the critical weed-free period, representing the duration the crop must be kept clean. The second curve defines the critical time of weed removal, identifying the maximum period weeds can coexist before causing yield loss.

205. (B) P-2, Q-4, R-1, S-3
Threshold concepts are essential for economic weed management. The damage boundary is the lowest weed density causing measurable yield loss. The economic threshold is the density where control costs equal saved yield value. The action threshold determines when to initiate control to prevent reaching the economic threshold, while aesthetic thresholds govern visually sensitive ornamental landscapes.

206. (B) The allelochemicals are released from the plant in their toxic, active form
True allelopathy is distinguished from functional allelopathy based on the metabolic state of the released compounds. In true allelopathy, the plant directly synthesizes and exudes compounds that are immediately phytotoxic to surrounding plants in their original form. In contrast, functional allelopathy requires soil microorganisms to first transform non-toxic precursor compounds into active toxins.

207. (A) The phase of the moon during the planting of the crop seed
Successional dynamics of weed flora in continuous cropping systems are driven by tangible agricultural practices, such as the repeated use of specific herbicide modes of action, tillage intensity, and crop rotation sequences. However, the lunar phase during crop planting does not exert any measurable biological or ecological influence on weed seed germination or species shifts.

208. (A) II, III, I, IV
The historical development of chemical weed control occurred in distinct phases. Inorganic salts like copper sulfate were used in the late nineteenth century. Synthetic auxins, such as 2,4-D, were discovered in the nineteen-forties. EPSPS inhibitors, primarily glyphosate, were commercialized in the nineteen-seventies, followed by ALS inhibitors like sulfonylureas in the late nineteen-seventies and eighties.

209. (D) Fine solid particles of active ingredient suspended stably in a liquid medium
A suspension concentrate is a specific liquid herbicide formulation developed for insoluble active ingredients. It is manufactured by grinding the solid herbicide into extremely fine particles, which are then stably suspended in a liquid carrier, typically water, using dispersing agents. This formulation combines the handling ease of liquids with the efficacy of solid active ingredients.

210. (C) Accumulation of reactive oxygen species destroying cell membranes via lipid peroxidation
Protox inhibitor herbicides block the protoporphyrinogen oxidase enzyme, which leads to an accumulation of protoporphyrin IX in the cytoplasm. In the presence of light, this molecule interacts with oxygen to generate highly reactive singlet oxygen species. These free radicals rapidly peroxidize lipid membranes, causing rapid cell leakage, membrane collapse, and foliar necrosis.

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CHAPTER 03
Soil Fertility and Fertilizer Use

2008

1. Which fundamental law of soil fertility states that plant growth is limited by the nutrient present in the lowest relative amount?
(A) Bray's Nutrient Mobility Concept
(B) Liebig's Law of the Minimum
(C) Mitscherlich's Law of Diminishing Returns
(D) Macy's Concept of Critical Concentration

2018

2. According to Mitscherlich's equation, what relationship exists between plant growth and the addition of a limiting nutrient?
(A) Plant growth increases in a strictly linear pattern with every successive nutrient addition.
(B) Yield responds to nutrient application only after a certain critical threshold is surpassed.
(C) Plant growth is inversely proportional to the tissue concentration of the limiting nutrient.
(D) Yield increase per unit of added nutrient declines as the maximum yield is approached.

2004

3. Under Bray's nutrient mobility concept, which of the following best describes the behavior of mobile nutrients?
(A) They are primarily extracted from the entire volume of soil water within the root zone.
(B) They are strongly adsorbed to soil colloids and require direct root contact.
(C) Their availability to plants is largely independent of the root system's volume.
(D) They are extracted from a specific localized zone termed the root system sorption zone.

2011

4. Which of the following equations correctly represents the integrated form of Mitscherlich's Law of Diminishing Returns, where A is the maximum yield, y is the yield with x amount of nutrient, and c is the proportionality constant?
(A) $\log(A - y) = \log A + cx$
(B) $\log(A + y) = \log A - cx$
(C) $\log(A - y) = \log A - cx$
(D) $\log(A - y) = \log y - cx$

2021

5. In the context of historical soil fertility milestones, who is credited with introducing the concept that nutrients must be in an available form for plant uptake, rather than just present in the soil?
(A) Roger Bray
(B) Justus von Liebig
(C) Eilhard Mitscherlich
(D) Jethro Tull

2007

6. Which of the following best explains why Liebig's Law of the Minimum is primarily applicable to highly deficient soils?
(A) It assumes that synergistic interactions among different soil nutrients are completely absent.
(B) It asserts that adding any non-limiting nutrient will increase the overall crop yield.
(C) It applies exclusively to macronutrient requirements while ignoring micronutrient deficiencies.
(D) It fails to consider nutrient interactions and substitution as soil fertility improves.

2002

7. According to Bray's concept, how do plants primarily acquire immobile nutrients like phosphorus?
(A) Through the passive mass flow of water moving directly to the root surface.
(B) By root interception and diffusion over relatively short distances.
(C) Through active luxury consumption mechanisms during early vegetative growth.
(D) By releasing root exudates to mobilize the entire insoluble phosphorus pool.

2015

8. What is the primary limitation of Mitscherlich's original equation when applied to field conditions?
(A) It requires the continuous presence of toxic micronutrient levels to be accurate.
(B) It is incapable of calculating the maximum theoretical crop yield.

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(C) It assumes the proportionality constant (c) remains constant under all conditions.
(D) It focuses exclusively on physical soil properties rather than chemical plant nutrients.

2007
9. Identify the INCORRECT statement regarding the fundamental laws of soil fertility.
(A) Liebig's Law implies a linear response to the limiting nutrient until another nutrient becomes limiting.
(B) Mitscherlich's Law states that yield increases logarithmically with nutrient additions.
(C) Bray's concept divides nutrients into mobile and immobile categories based on their movement in the soil.
(D) Mitscherlich's equation perfectly predicts yield depressions caused by excessive fertilizer application.

2012
10. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A): Sodium is considered a functional element rather than an essential element for most higher plants.
Reason (R): To be classified as essential, an element must be universally required by all plants to complete their life cycle, whereas sodium is only required by certain specialized species or can partially substitute for potassium in some plants.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004
11. Which two scientists formulated the criteria of essentiality for plant nutrients?
(A) Liebig and Mitscherlich
(B) Arnon and Stout
(C) Bray and Kurtz
(D) Olsen and Sommers

2013
12. Which of the following is NOT one of the standard criteria for nutrient essentiality in plants?
(A) A deficiency of the element makes it impossible for the plant to complete its vegetative or reproductive stage.
(B) The element significantly increases crop yield under all environmental conditions.
(C) The deficiency is specific to the element and can be prevented or corrected only by supplying that element.
(D) The element is directly involved in the nutrition of the plant.

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2022
13. Which of the following groups contains only beneficial elements for higher plants?
(A) Silicon, Cobalt, Sodium, Vanadium
(B) Iron, Manganese, Zinc, Copper
(C) Nickel, Molybdenum, Boron, Chlorine
(D) Calcium, Magnesium, Sulfur, Phosphorus

2014
14. What distinguishes a "functional element" from an "essential element" in plant nutrition?
(A) A functional element is required by all plant species, whereas an essential element is restricted to specific plant families.
(B) Functional elements are absorbed only through leaf tissues, whereas essential elements are absorbed only through root systems.
(C) A functional element promotes growth or substitutes for another, but is not strictly required to complete the life cycle.
(D) Functional elements are highly toxic at elevated concentrations, whereas essential elements are beneficial at all levels.

2012
15. Consider the following statements regarding the criteria of essentiality:
I. The element must be directly involved in plant metabolism.
II. Beneficial elements can substitute completely for essential elements.
III. Nickel is classified as an essential micronutrient.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2021
16. Which essential element is required for the activation of the enzyme urease in plants?
(A) Cobalt
(B) Molybdenum
(C) Nickel
(D) Zinc

2022

17. Identify the correct pair of element and its classification.
(A) Chlorine – Beneficial element
(B) Silicon – Beneficial element
(C) Cobalt – Essential macronutrient
(D) Molybdenum – Functional element

2004

18. Why was Nickel added to the list of essential elements much later than others?
(A) It is exclusively required by aquatic plant species and has no role in terrestrial agriculture.
(B) It acts primarily as a soil-applied fungicide rather than acting as a metabolic plant nutrient.
(C) It is heavily bound within complex soil organic matter matrices and is completely unavailable.
(D) It is required in such minute quantities that inducing deficiency is extremely difficult.

2008

19. What is the primary mechanism of nutrient transport from soil to roots for highly soluble and mobile ions like nitrate (NO_3^-)?
(A) Mass flow
(B) Root interception
(C) Diffusion
(D) Active transport across the soil matrix

2015

20. Match the nutrient transport mechanisms listed in List I with their primary driving forces or characteristics listed in List II:
List I: (Transport Mechanisms)
P. Mass flow
Q. Diffusion
R. Root interception
S. Ion exchange
List II: (Characteristics)
1. Driven by a concentration gradient
2. Nutrient acquisition through physical root extension into new soil volume
3. Driven by the transpirational water uptake of the plant
4. Replacement of one adsorbed ion by another on a soil colloid
(A) P-2, Q-1, R-4, S-3
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-1, Q-3, R-2, S-4

2005

21. Which nutrient is predominantly supplied to plant roots via diffusion because of its low concentration in the soil solution?
(A) Phosphorus
(B) Calcium
(C) Magnesium
(D) Nitrogen

2024

22. In the context of nutrient acquisition, how does a decrease in soil moisture primarily affect the transport of phosphorus?
(A) It increases transpirational mass flow, thereby enhancing phosphorus uptake.
(B) It increases physical root interception by forcing roots to grow much faster.
(C) It accelerates the chemical desorption of phosphorus from clay minerals.
(D) It reduces the water-filled pore space, restricting phosphorus diffusion.

2002

23. Which of the following correctly describes the process of root interception?
(A) Nutrients move directly to the root surface along a localized concentration gradient.
(B) Roots grow into new soil volume, directly contacting and absorbing available nutrients.
(C) Nutrients are actively carried to the root in the convective transpiration flow of water.
(D) Roots secrete acidic exudates to solubilize fixed nutrients from soil organic matter.

2019

24. Which sequence correctly orders the mechanisms of nutrient transport based on their typical contribution to potassium uptake in most agricultural soils (from largest to smallest)?
(A) Diffusion, Mass flow, Root interception
(B) Mass flow, Diffusion, Root interception
(C) Root interception, Diffusion, Mass flow
(D) Diffusion, Root interception, Mass flow

2004

25. Consider the following statements regarding nutrient transport:
I. Mass flow is the primary mechanism for calcium uptake.
II. Diffusion is highly dependent on soil temperature and moisture.
III. Root interception accounts for the majority of nitrogen uptake.
IV. High transpiration rates increase nutrient supply via mass flow.
Which of the above statement(s) is/are

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INCORRECT?
(A) I and II
(B) II and IV
(C) III only
(D) I, III and IV

2016

26. How does the cation exchange capacity (CEC) of a soil influence nutrient dynamics?
(A) High CEC soils maintain a larger reserve of exchangeable cations to replenish the soil solution.
(B) Higher CEC soils hold significantly fewer basic cations against leaching into groundwater.
(C) CEC strictly determines the diffusion rate of essential anions through the soil solution.
(D) High CEC soils require lower fertilizer rates to maintain solution potassium concentrations.

2016

27. Which equation or law governs the rate of nutrient diffusion in the soil solution?
(A) Stokes' Law
(B) Fick's First Law
(C) Darcy's Law
(D) Mitscherlich's Equation

2016

28. What does "hidden hunger" refer to in the context of plant nutrition?
(A) The rapid, visual manifestation of severe nutrient deficiency on older leaves.
(B) A sub-critical nutrient deficiency that reduces yield without visible symptoms.
(C) The excessive luxury consumption of nutrients beyond what is needed for yield.
(D) A physiological state where roots cannot access nutrients due to severe drought.

2011

29. According to Macy's yield-response curve, the "poverty adjustment" zone represents which phase of plant growth?
(A) The phase where both plant yield and tissue nutrient concentration increase simultaneously.
(B) The phase where crop yield remains entirely constant while tissue concentration increases.
(C) The phase where overall crop yield decreases significantly due to severe nutrient toxicity.
(D) The phase where crop yield increases while the nutrient concentration in tissues decreases.

2012

30. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A): Luxury consumption occurs when plants absorb more of a nutrient than is required for maximum growth and yield.
Reason (R): Potassium is the nutrient most frequently associated with luxury consumption in agronomic crops.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

31. How is the "critical nutrient concentration" formally defined in plant tissue analysis?
(A) The concentration of a nutrient at which maximum theoretical yield is achieved.
(B) The minimum concentration required to prevent visual deficiency symptoms.
(C) The concentration beyond which further uptake causes toxicity and yield decline.
(D) The concentration in plant tissue associated with a 10% reduction from maximum yield.

2004

32. In Macy's concept, the "minimum percentage" phase refers to a situation where:
(A) Both crop yield and internal tissue nutrient concentration decline simultaneously.
(B) Crop yield reaches its peak and further nutrient additions do not affect growth.
(C) Yield increases with nutrient addition while tissue concentration remains constant.
(D) The applied nutrient becomes highly toxic and severely inhibits root development.

2001

33. Which condition poses a significant economic disadvantage for farmers unaware of luxury consumption?
(A) Application of chemical fertilizer improves yield but severely reduces crop quality.
(B) Fertilizer is applied and luxury uptake occurs without increasing total crop yield.
(C) Crops fail to absorb any soil-applied fertilizer due to rapid nutrient fixation.
(D) Crops exhibit severe deficiency symptoms despite maintaining high soil test levels.

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2003

34. Identify the INCORRECT statement regarding critical nutrient concentrations.
(A) They help differentiate between hidden hunger and adequate nutrient status.
(B) They usually vary depending on the physiological age of the plant.
(C) They are determined using yield-response curves based on tissue testing.
(D) They are constant for a given crop species regardless of the plant part sampled.

2012

35. Consider the following statements about Macy's yield-response curve:
I. The minimum percentage zone is characterized by yield increases with no change in tissue nutrient concentration.
II. The poverty adjustment zone shows increases in both yield and tissue concentration.
III. The luxury consumption zone shows no yield increase, but tissue concentration rises.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2010

36. Which plant physiological stage is generally most appropriate for sampling to evaluate critical nutrient concentrations to guide fertilizer recommendations?
(A) Early seedling emergence and initial establishment phase.
(B) Late senescence when nutrients are translocated to seeds.
(C) Active vegetative growth or just prior to flowering.
(D) Post-harvest residue and stubble left in the field.

2022

37. Which secondary macronutrient serves as the central coordinating atom in the chlorophyll molecule?
(A) Calcium
(B) Magnesium
(C) Sulfur
(D) Iron

2010

38. What is the characteristic mobility pattern and deficiency symptom of Magnesium in plants?
(A) Highly immobile; interveinal chlorosis on new leaves.
(B) Moderately mobile; purpling of leaf margins on older leaves.
(C) Immobile; necrosis of the apical meristem.
(D) Highly mobile; interveinal chlorosis on older leaves.

2013

39. Which of the following describes the primary physiological role of Potassium in plants?
(A) It serves as a vital structural component of nucleic acids and phospholipids.
(B) It regulates stomatal movement, cell osmoregulation, and enzyme activation.
(C) It functions as the central coordinating atom in the chlorophyll porphyrin ring.
(D) It is directly required for synthesizing the middle lamella in plant cell walls.

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2019

40. Match the macronutrients listed in List I with their classic deficiency symptoms listed in List II:
List I: (Macronutrients)
P. Phosphorus
Q. Potassium
R. Calcium
S. Sulfur
List II: (Deficiency Symptoms)
1. Marginal necrosis or "firing" on older leaves
2. Dark green foliage with purplish coloration on older leaves
3. Uniform chlorosis of younger leaves first
4. Death of terminal buds and "blossom-end rot" in fruits
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-3, S-4
(D) P-3, Q-1, R-4, S-2

2010

41. Why do sulfur deficiency symptoms typically appear first on younger leaves?
(A) Sulfur is rapidly mobilized from younger to older vegetative tissues during periods of stress.
(B) Younger leaves maintain a significantly higher metabolic demand for sulfur than older leaves.
(C) Sulfur is continuously leached out of older leaves by high rates of transpirational water loss.
(D) Sulfur is relatively immobile and cannot be easily redistributed from older to younger tissues.

2018

42. Which secondary macronutrient is essential for the formation of calcium pectate in the middle lamella, providing structural stability to cell walls?
(A) Calcium
(B) Magnesium
(C) Phosphorus
(D) Sulfur

2018

43. Nitrogen deficiency manifests primarily as uniform chlorosis on older leaves. What physiological principle explains this pattern?
(A) Nitrogen is entirely immobile within both the xylem and phloem transport pathways.
(B) Nitrogen is highly mobile and is translocated from older to newer plant tissues.
(C) Nitrogen is locked in vacuoles of older leaves, directly degrading chlorophyll.
(D) Older leaves transpire more water, leading to a rapid physical loss of nitrogen.

2013

44. Identify the INCORRECT pair of nutrient and its physiological role.
(A) Phosphorus – Energy transfer (ATP/ADP)
(B) Calcium – Stomatal regulation and osmoregulation
(C) Sulfur – Component of amino acids like cysteine and methionine
(D) Magnesium – Ribosome structure and chlorophyll synthesis

2017

45. Consider the following statements about macronutrient mobility:
I. Nitrogen, Phosphorus, and Potassium are highly mobile in plants.
II. Calcium and Boron are highly mobile in plants.
III. Magnesium mobility allows its deficiency to appear on older leaves.
IV. Sulfur is considered highly mobile within plant tissues.
Which of the above statement(s) is/are correct?
(A) I and III
(B) II and IV
(C) I, II and III
(D) I and IV

2006

46. Zinc deficiency in plants frequently leads to shortened internodes, a condition commonly referred to as "rosetting". This occurs due to the role of zinc in the synthesis of which plant hormone?
(A) Cytokinin
(B) Gibberellic acid
(C) Indole-3-acetic acid (Auxin)
(D) Abscisic acid

2012

47. "Khaira" disease in rice is a classic indicator of the deficiency of which micronutrient?
(A) Iron
(B) Manganese
(C) Copper
(D) Zinc

2010

48. Which micronutrient deficiency is primarily responsible for "Whiptail" disease in cauliflower?
(A) Boron
(B) Chlorine
(C) Molybdenum
(D) Nickel

2001

49. Iron deficiency is visually characterized by:
(A) Uniform chlorosis developing primarily on older leaves.
(B) Interveinal chlorosis on younger leaves with green veins.
(C) Distinct purpling of the margins on older lower leaves.
(D) Dark necrotic spots appearing on stems and leaf petioles.

2018

50. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A): Molybdenum deficiency is more severe in highly acidic soils.
Reason (R): The availability of molybdenum decreases as soil pH decreases.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

51. Which plant is widely regarded as a classic indicator plant for Boron deficiency?
(A) Sunflower
(B) Maize
(C) Rice
(D) Potato

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2023

52. "Pahala blight" in sugarcane and "Grey speck" in oats are physiological disorders associated with the deficiency of:
(A) Copper
(B) Iron
(C) Manganese
(D) Zinc

2006

53. What is the central physiological role of Boron in higher plants?
(A) It aids cell wall synthesis, sugar transport, and pollen tube growth.
(B) It serves as an essential structural component of the nitrogenase enzyme.
(C) It acts directly as an active electron carrier during photosynthesis.
(D) It is the primary element regulating stomatal opening and closure.

2021

54. Emerging deficiencies of which micronutrient are becoming increasingly common in high-yielding, intensively cultivated areas, partly due to the shift towards high-analysis fertilizers?
(A) Chlorine
(B) Cobalt
(C) Vanadium
(D) Zinc

2015

55. Consider the following statements about nutrient interactions:
I. Synergism occurs when the combined effect of two nutrients is greater than the sum of their individual effects.
II. Mulder's interaction chart visually represents only the antagonistic relationships between elements.
III. High levels of phosphorus can induce zinc deficiency in plants.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2013

56. The well-documented P-Zn antagonism in plants generally occurs because:
(A) Phosphorus directly precipitates zinc in the soil solution as zinc phosphate.
(B) Phosphorus and zinc compete for the same carrier proteins in the root cell membrane.
(C) Excessive phosphorus inhibits the translocation of zinc from roots to shoots.
(D) Zinc promotes the excessive uptake of phosphorus leading to toxicity.

2024

57. Which of the following nutrient pairs typically exhibits a strong synergistic relationship in terms of plant uptake?
(A) Potassium and Magnesium
(B) Iron and Manganese
(C) Calcium and Boron
(D) Nitrogen and Phosphorus

2013

58. According to Mulder's interaction chart, high concentrations of Potassium in the soil often lead to an antagonistic reduction in the uptake of which nutrient?
(A) Magnesium
(B) Phosphorus
(C) Nitrogen
(D) Sulfur

2022

59. Which type of interaction is observed when the application of nitrogen fertilizer increases the plant's efficiency in utilizing available soil phosphorus?
(A) Antagonism
(B) Synergism
(C) Null interaction
(D) Luxury consumption

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2008

60. Match the nutrient interactions listed in List I with their specific nature listed in List II:
List I: (Nutrient Interactions)
P. N application on P uptake
Q. Excessive P on Zn uptake
R. Excessive K on Mg uptake
S. Excessive Ca on B availability
List II: (Nature of Interaction)
1. Induces Zinc deficiency
2. Synergistic interaction enhancing uptake
3. Induces Magnesium deficiency
4. Decreases Boron availability
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-2, S-4

2006

61. Heavy applications of calcitic limestone (calcium carbonate) can most likely induce a deficiency of which set of micronutrients due to increased pH and calcium antagonism?

(A) Iron, Manganese, and Zinc
(B) Molybdenum and Chlorine
(C) Boron and Molybdenum
(D) Nitrogen and Potassium

2016

62. Which of the following represents an antagonistic interaction at the root surface caused by ionic competition?
(A) NO_3^- suppressing $PO_4^{\{3-\}}$ uptake
(B) $SO_4^{\{2-\}}$ enhancing $MoO_4^{\{2-\}}$ uptake
(C) NH_4^+ suppressing K^+ uptake
(D) $Ca^{\{2+\}}$ enhancing $Mg^{\{2+\}}$ uptake

2017

63. How does Mulder's interaction chart primarily aid agronomists?
(A) It calculates the exact fertilizer dose required for maximum crop yield.
(B) It predicts the physical movement of soluble nutrients through mass flow.
(C) It details the biochemical pathways of biological nitrogen fixation.
(D) It maps synergistic and antagonistic interactions among plant nutrients.

2012

64. What is the fundamental basis of the Diagnosis and Recommendation Integrated System (DRIS) used in plant tissue analysis?
(A) It relies exclusively on determining absolute critical nutrient concentrations in older leaves.
(B) It measures the physical sap flow rate to determine overall plant nutrient uptake efficiency.
(C) It uses ratios of nutrient concentrations to diagnose nutrient balance and deficiencies.
(D) It assesses active soil microbial biomass to accurately predict tissue nutrient content.

2013

65. Consider the following statements about DRIS:
I. DRIS indices are less affected by the physiological age of the plant than critical nutrient concentrations.
II. A DRIS index value of zero indicates that the nutrient is optimally balanced relative to other nutrients.
III. Negative DRIS indices indicate that a nutrient is present in relative excess.
IV. Positive DRIS indices indicate a relative deficiency of that nutrient.
Which of the above statement(s) is/are correct?
(A) I and II
(B) III and IV
(C) I, II and III
(D) II and IV

2010

66. Compared to the critical level approach, what is the primary advantage of using DRIS for plant tissue diagnostics?
(A) DRIS requires only a single, easily analyzed index nutrient to make accurate diagnoses.
(B) DRIS indices can be calculated without establishing any high-yielding reference norms.
(C) DRIS completely eliminates any need for supplementary soil chemical testing procedures.
(D) DRIS indices are relatively independent of dry matter dilution and crop growth stage.

2017

67. Which diagnostic tool provides a rapid, in-field, semi-quantitative measurement of nitrate or potassium concentrations in plant tissues?
(A) Leaf sap testing using portable electrodes or strips.
(B) Diagnosis and Recommendation Integrated System (DRIS) models.
(C) Inductively Coupled Plasma atomic emission spectroscopy.
(D) The standard laboratory Critical Level Approach method.

2009

68. In the critical level approach to tissue diagnosis, the "critical limit" is generally accepted as the nutrient concentration in a specific plant part at a specific growth stage that results in:
(A) 50% of maximum yield
(B) 90% of maximum yield
(C) 100% of maximum yield
(D) Maximum vegetative biomass without considering reproductive yield

2009

69. Why is standardization of the plant part and sampling time strictly necessary when using the critical level approach?
(A) Because nutrient concentrations vary with physiological age and among different plant organs.
(B) Because nutrient concentrations in tissues fluctuate wildly based on wind speed and wind direction.
(C) Because standardizing these specific variables is strictly required to calculate

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basic DRIS norms.
(D) Because rapid sap tests can only be successfully performed under dark conditions at midnight.

2006

70. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A): Rapid plant sap tests are highly useful for making mid-season nitrogen fertilizer adjustments.
Reason (R): Sap tests measure the unassimilated nutrient fraction moving through the plant, providing a real-time snapshot of current nutrient uptake.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

71. If a plant tissue analysis using DRIS returns indices of $N = -12$, $P = +4$, and $K = +8$, which nutrient is most limiting?
(A) Phosphorus
(B) Nitrogen
(C) Potassium
(D) All are equally limiting

2003

72. Which limitation is most commonly associated with the DRIS method?
(A) It is restricted in practice and can only be used on major cereal crops.
(B) It requires precise tissue sampling strictly at the peak flowering stage.
(C) It requires a large database of high-yielding reference crop populations.
(D) It is incapable of diagnosing multiple nutrient deficiencies simultaneously.

2002

73. Which standard soil extractant is most appropriate for determining available phosphorus in alkaline and calcareous soils?
(A) Bray-1 extractant (0.03 M NH_4F + 0.025 M HCl)
(B) Mehlich-3 extractant (dilute acid-fluoride-EDTA)
(C) Morgan's reagent (sodium acetate + acetic acid)
(D) Olsen's extractant (0.5 M Sodium Bicarbonate)

2001

74. The Bray-1 extractant for soil phosphorus is primarily composed of:
(A) 0.03 M NH_4F and 0.025 M HCl
(B) 0.5 M Sodium Bicarbonate
(C) 1 M Neutral Ammonium Acetate
(D) 0.005 M DTPA, 0.01 M CaCl2, and 0.1 M TEA

2014

75. Consider the following extraction methods and their target nutrients:
I. Neutral normal ammonium acetate - Exchangeable Potassium
II. DTPA extractant - Available Zinc, Copper, Iron, Manganese
III. Hot water extraction - Available Boron
IV. Olsen's method - Available Phosphorus in acidic soils
V. Walkley-Black method - Soil Organic Carbon
Which of the above statement(s) is/are correctly matched?
(A) I, II, III, V
(B) I, II, IV, V
(C) II, III, IV, V
(D) I, III, IV, V

2012

76. Why is the DTPA (Diethylenetriaminepentaacetic acid) extractant buffered at a pH of 7.3?
(A) To maximize the extraction of total heavy metals bound within the soil mineral matrix.
(B) To prevent carbonate dissolution and subsequent release of fixed micronutrients.
(C) To extract exchangeable acidity and hydrogen ions from the edges of clay particles.
(D) To ensure that soluble phosphorus is completely precipitated during the extraction.

NODIA

2006

77. Which soil test method is conventionally used to estimate available nitrogen in Indian soils?
(A) Alkaline potassium permanganate method
(B) Standard sulfuric acid Kjeldahl digestion
(C) Dilute ammonium fluoride Bray-1 extraction
(D) Buffered chelating agent DTPA extraction

2009

78. What does the "critical limit" of a nutrient in soil testing represent?
(A) The absolute total chemical amount of the nutrient present in the soil profile.
(B) The concentration level at which the nutrient

becomes toxic to microbes.
(C) The soil test value below which fertilizer response is highly probable.
(D) The background concentration of the nutrient dissolved in the groundwater.

2002
79. Which extractant is most commonly used for determining available sulfur in soils?
(A) 1 M Potassium Chloride (KCl)
(B) 0.5 M Sodium Bicarbonate ($NaHCO_3$)
(C) Neutral normal Ammonium Acetate
(D) 0.15% Calcium Chloride ($CaCl_2$)

2008
80. Match the soil property or nutrient listed in List I with its standard analytical method/extractant listed in List II:
List I: (Soil Properties)
P. Soil Organic Carbon
Q. Available Potassium
R. Available Phosphorus (Acid Soil)
S. Available Micronutrients (Zn, Fe)
List II: (Analytical Methods)
1. Neutral normal Ammonium Acetate
2. Walkley-Black Wet Oxidation
3. DTPA extraction
4. Bray-1 extraction
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-4, S-3
(C) P-2, Q-1, R-3, S-4
(D) P-4, Q-3, R-2, S-1

2025
81. Identify the INCORRECT statement regarding soil testing extractants.
(A) Olsen's extractant suppresses calcium activity in calcareous soils to release phosphorus.
(B) DTPA is highly effective in extracting total trace metals from silicate minerals.
(C) The fluoride ion in Bray-1 extractant complexes with aluminum to release phosphorus.
(D) Neutral normal ammonium acetate displaces exchangeable potassium from the soil exchange complex.

2006
82. What is the fundamental distinction between soil fertility and soil productivity?
(A) Soil fertility is defined by physical soil structure, whereas soil productivity is defined by chemical nutrient indices.
(B) Soil fertility describes microbial activity, while soil productivity describes the total mineral reserve of bedrock.
(C) There is no functional difference between fertility and productivity as both terms measure crop yield potential.
(D) Soil fertility is the nutrient-supplying capacity, whereas productivity is the yield performance under management.

2010
83. Which of the following statements best illustrates the relationship between fertility and productivity?
(A) A productive soil must be fertile, but a fertile soil may fail to produce due to environmental constraints.
(B) All fertile soils are inherently productive under field conditions regardless of local environmental stress.
(C) Soil productivity is evaluated in a laboratory, whereas soil fertility must be evaluated in open field trials.
(D) Soil fertility is primarily an economic business concept, whereas soil productivity is a purely chemical concept.

2004
84. Which of the following is NOT typically considered a parameter for evaluating soil productivity?
(A) The actual harvested crop yield per hectare.
(B) The net financial profitability of the crop.
(C) The inert primary minerals within the bedrock.
(D) The management inputs required to achieve yield.

2006
85. Good soil management aims to enhance productivity by doing all of the following EXCEPT:
(A) Promoting continuous monoculture cropping systems.
(B) Maintaining or increasing total organic matter.
(C) Optimizing soil pH for maximum nutrient release.
(D) Improving soil structure and water retention.

2012
86. Which parameter is a primary indicator of soil fertility rather than overall soil productivity?
(A) Climate and rainfall distribution
(B) Economic return on investment
(C) Access to irrigation infrastructure

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(D) Cation Exchange Capacity (CEC)

2012

87. A farmer possesses a soil that is rich in all essential nutrients, yet crop yields are consistently poor due to severe waterlogging. This soil is:
(A) Infertile but productive
(B) Fertile but unproductive
(C) Infertile and unproductive
(D) Fertile and productive

2015

88. How does soil organic matter (SOM) contribute to both soil fertility and productivity?
(A) By exclusively supplying essential trace micronutrients to the growing crops.
(B) By increasing soil bulk density to provide physically stronger root anchorage.
(C) By supplying slow-release nutrients and improving physical soil structure.
(D) By lowering rhizosphere pH values to highly acidic and corrosive levels.

2018

89. Which evaluation parameter integrates soil, climate, and management factors to assess land capability?
(A) Soil Test Value
(B) Plant Tissue Critical Limit
(C) Mitscherlich Yield Coefficient
(D) Storie Index Rating

2008

90. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A): Soil productivity is dynamic and can be altered by human management practices.
Reason (R): Practices like irrigation, drainage, and fertilization directly address the physical, chemical, and environmental constraints limiting crop growth.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

91. A fertilizer containing only one of the primary macronutrients (N, P, or K) is classified as a:
(A) Complex fertilizer
(B) Straight fertilizer
(C) Mixed fertilizer
(D) Complete fertilizer

2019

92. Which of the following is an example of a straight nitrogenous fertilizer?
(A) Diammonium Phosphate (DAP)
(B) Urea
(C) Potassium Nitrate
(D) Nitrophosphate

2025

93. How does a complex fertilizer differ from a mixed fertilizer?
(A) Complex fertilizers are chemically combined, whereas mixed fertilizers are physical blends.
(B) Complex fertilizers are always manufactured as liquids, whereas mixed fertilizers are dry solids.
(C) Complex fertilizers contain only micronutrients, whereas mixed fertilizers contain macronutrients.
(D) Complex fertilizers maintain a lower total nutrient grade than standard physically mixed fertilizers.

2017

94. Diammonium Phosphate (DAP) contains which primary nutrients, and in what typical percentages (N-P2O5)?
(A) 46% N, 18% P2O5
(B) 12% N, 32% P2O5
(C) 18% N, 46% P2O5
(D) 21% N, 0% P2O5

2025

95. Consider the following statements about fertilizer materials:
I. Urea is an organic fertilizer in chemical structure but is considered a synthetic nitrogen fertilizer in agriculture.
II. Muriate of Potash (MOP) is a complex fertilizer.
III. Liquid fertilizers have the advantage of uniform application and compatibility with fertigation.
IV. Single Super Phosphate (SSP) contains significant amounts of calcium and sulfur in addition to phosphorus.
V. Bulk blending requires materials of similar particle size to prevent segregation.
Which of the above statement(s) is/are correct?
(A) I, III, IV, V
(B) I, II, III, V
(C) II, III, IV, V
(D) I, II, IV, V

NODIA

2001

96. What is a primary disadvantage of using physically mixed fertilizers if the granular materials differ significantly in size and density?
(A) Caking during storage
(B) Loss of nitrogen through volatilization
(C) Segregation during transport and application
(D) Exothermic reactions causing spontaneous combustion

2014

97. Which of the following fertilizers has the highest nitrogen content by weight among solid nitrogenous fertilizers?
(A) Ammonium Nitrate
(B) Urea
(C) Ammonium Sulfate
(D) Calcium Ammonium Nitrate (CAN)

2023

98. An example of a clear liquid fertilizer containing nitrogen and phosphorus commonly used as a starter fertilizer is:
(A) Anhydrous ammonia
(B) Liquid urea
(C) Muriate of potash solution
(D) Ammonium polyphosphate

2001

99. The biological conversion of organic nitrogen into inorganic ammonium (NH_4^+) is known as:
(A) Mineralization (Ammonification)
(B) Nitrification
(C) Denitrification
(D) Immobilization

2009

100. Match the nitrogen transformation processes listed in List I with the primary mediating microorganisms listed in List II:
List I: (Transformation Processes)
P. Ammonification
Q. Nitrification (Step 1: $NH_4^+ \rightarrow NO_2^-$)
R. Nitrification (Step 2: $NO_2^- \rightarrow NO_3^-$)
S. Denitrification
List II: (Microorganisms)
1. Nitrosomonas
2. Nitrobacter
3. Pseudomonas and Bacillus (under anaerobic conditions)
4. Diverse heterotrophic bacteria and fungi
(A) P-4, Q-1, R-2, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-1, Q-4, R-2, S-3
(D) P-3, Q-1, R-2, S-4

2002

101. Which condition most strongly favors the process of ammonia volatilization?
(A) Surface application of urea on alkaline, calcareous soils.
(B) Deep placement of urea in acidic soils.
(C) Incorporation of ammonium sulfate in cold, waterlogged soils.
(D) Application of anhydrous ammonia via deep injection.

2010

102. Denitrification results in the loss of soil nitrogen primarily in the form of:
(A) NH_3 gas
(B) NO_3^- leached into groundwater
(C) NH_4^+ fixed in clay lattices
(D) N_2O and N_2 gases

NODIA

2006

103. The immobilization of nitrogen in soil is most likely to occur when incorporating crop residues with a Carbon-to-Nitrogen (C:N) ratio of:
(A) 10:1
(B) 15:1
(C) 20:1
(D) 60:1

2003

104. Which biological process is strictly aerobic and heavily dependent on adequate soil moisture and temperature?
(A) Denitrification
(B) Ammonia volatilization
(C) Nitrification
(D) Biological nitrogen fixation by Clostridium

2022

105. Consider the following compounds involved in the nitrogen mineralization and nitrification process:
I. Nitrite (NO_2^-)
II. Organic Nitrogen
III. Nitrate (NO_3^-)
IV. Ammonium (NH_4^+)
Which of the following represents the correct chronological order starting from organic nitrogen?
(A) II, IV, I, III
(B) II, I, IV, III
(C) IV, II, I, III
(D) II, IV, III, I

2017

106. Identify the INCORRECT statement regarding nitrogen reactions in soil.

(A) Immobilization results in a permanent loss of nitrogen from the soil ecosystem.
(B) Nitrification lowers soil pH by releasing hydrogen ions.
(C) Mineralization is carried out by heterotrophic microorganisms.
(D) Denitrification thrives under anaerobic conditions such as waterlogged soils.

2007

107. When urea is applied to the soil, it rapidly undergoes hydrolysis catalyzed by the enzyme urease. What are the immediate products of this reaction?
(A) Nitrate and Water
(B) Ammonium and Carbon dioxide
(C) Nitrite and Oxygen
(D) Urea-formaldehyde and Ammonia

2004

108. In highly acidic soils, applied phosphorus fertilizer is predominantly fixed by which elements?
(A) Calcium and Magnesium
(B) Iron and Aluminum
(C) Potassium and Sodium
(D) Zinc and Copper

2017

109. Which of the following phosphorus fertilizers is classified as water-soluble?
(A) Single super phosphate
(B) Insoluble rock phosphate
(C) Citric dicalcium phosphate
(D) Natural bone meal powder

2025

110. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Rock phosphate is more effective when applied to strongly acidic soils than to alkaline soils.
Reason (R): Acidic conditions promote the dissolution of the apatite minerals in rock phosphate, releasing plant-available phosphorus.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

111. In calcareous, alkaline soils, phosphorus is primarily fixed through precipitation reactions to form insoluble compounds of:
(A) Aluminum phosphate
(B) Iron phosphate
(C) Magnesium phosphate
(D) Calcium phosphate

2016

112. Which classification accurately describes Basic Slag?
(A) Water-soluble P fertilizer
(B) Water-insoluble P fertilizer
(C) Citric-soluble P fertilizer
(D) Nitrogen-potassium fertilizer

2018

113. What is the phenomenon where the availability of fixed phosphorus slightly increases over time in soils under specific conditions, often due to organic acid exudation?
(A) P-fixation
(B) P-solubilization
(C) P-immobilization
(D) P-precipitation

2010

114. Consider the following statements about phosphorus fertilizers:
I. Water-soluble P fertilizers are best suited for alkaline and neutral soils.
II. Citric acid-soluble P fertilizers are effective in moderately acidic soils.
III. Insoluble P fertilizers like rock phosphate are entirely useless in agriculture.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2025

115. Consider the following phosphorus fertilizer materials:
I. Single Super Phosphate (SSP)
II. Triple Super Phosphate (TSP)
III. Dicalcium Phosphate (DCP)
IV. Rock Phosphate
V. Basic Slag
Which combination identifies ONLY the water-soluble phosphorus fertilizers?
(A) I and II
(B) III and IV
(C) I, II and V
(D) IV and V

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2019
116. Which of the following is an expected initial reaction product when water-soluble phosphorus fertilizer like TSP is applied to a neutral soil?
(A) Variscite (aluminum phosphate compound)
(B) Strengite (hydrated iron phosphate)
(C) Dicalcium phosphate dihydrate
(D) Fluorapatite (insoluble rock mineral)

2005
117. What is the primary mechanism by which polymer-coated urea (PCU) controls the release of nitrogen?
(A) Controlled diffusion of urea through the polymer membrane.
(B) Chemical inhibition of the urease enzyme in the soil.
(C) Direct microbial degradation of the outer polymer coating.
(D) Insoluble complexation with exchangeable soil aluminum.

2008
118. Sulfur-coated urea (SCU) releases nitrogen into the soil primarily as a result of:
(A) Water absorption leading to osmotic bursting of the coating.
(B) Direct chemical inhibition of the soil nitrification process.
(C) Gradual physical sublimation of the outer sulfur coating.
(D) Microbial oxidation and breakdown of the sulfur coating.

2018
119. Neem-coated urea relies on the properties of neem extract primarily to function as a:
(A) Phosphate solubilizer
(B) Nitrification inhibitor
(C) Soil urease inhibitor
(D) Heavy metal chelator

2001
120. Which of the following describes a key advantage of controlled-release fertilizers over conventional soluble fertilizers?
(A) They provide an immediate, rapid spike in nutrient availability.
(B) They are much cheaper to manufacture than conventional urea.
(C) They match nutrient release with crop uptake, reducing losses.
(D) They completely eliminate the need for phosphorus and potassium.

2015
121. The chemical compound urea-formaldehyde (UF) is classified as a:
(A) Coated controlled-release nitrogen
(B) Synthetic nitrification inhibitor
(C) Organic-based soil urease inhibitor
(D) Slow-release nitrogen fertilizer

2008
122. Which environmental factor has the most significant influence on the nutrient release rate of polymer-coated fertilizers?
(A) Soil temperature
(B) Soil pH
(C) Soil microbial biomass
(D) Soil organic matter content

2021
123. Identify the INCORRECT statement regarding slow and controlled-release fertilizers.
(A) Slow-release fertilizers typically rely on microbial action or chemical hydrolysis for nutrient release.
(B) Neem-coated urea reduces ammonia volatilization by acting as a strong urease inhibitor.
(C) Controlled-release fertilizers often use semi-permeable polymer coatings to govern release kinetics.
(D) The release rate of sulfur-coated urea can be variable due to non-uniform coating thickness and microbial activity.

NODIA

2017
124. What is the active principle in neem cake/neem oil that retards the activity of Nitrosomonas bacteria?
(A) Hydroquinone chemical compound
(B) Meliacin (epimeliacins)
(C) NBPT (urease inhibitor)
(D) Dicyandiamide compound

2022
125. Determine the correct sequence of nitrogen release from Polymer-Coated Urea (PCU):
I. Diffusion of dissolved urea out of the granule
II. Water vapor diffuses into the granule through the coating
III. Hydrolysis of urea by soil urease
IV. Dissolution of the solid urea core
Select the correct sequence from the options below:
(A) II, IV, I, III
(B) IV, II, I, III
(C) II, I, IV, III
(D) I, II, IV, III

2021

126. Which of the following compounds is a widely used commercial nitrification inhibitor?
(A) N-(n-butyl) thiophosphoric triamide (NBPT)
(B) Phenylphosphorodiamidate (PPD)
(C) Nitrapyrin (N-Serve)
(D) Hydroquinone

2015

127. The primary biochemical mechanism of urease inhibitors like NBPT is to:
(A) Direct bactericidal action against Nitrosomonas populations.
(B) Significantly elevate soil pH to prevent ammonia loss.
(C) Form an insoluble, highly stable complex with urea molecules.
(D) Competitively block the active site of the urease enzyme.

2012

128. Dicyandiamide (DCD) functions in soil nitrogen management by:
(A) Specifically depressing the activity of Nitrobacter.
(B) Significantly enhancing biological nitrogen fixation.
(C) Depressing Nitrosomonas activity to slow nitrification.
(D) Directly inhibiting the soil denitrification pathway.

2025

129. Why is hydroquinone used in conjunction with urea fertilizers?
(A) It acts as a nitrification inhibitor, preventing leaching.
(B) It acts as a urease inhibitor, reducing volatilization.
(C) It provides supplemental carbon to stimulate soil microbes.
(D) It acts as a physical barrier coating on the urea granule.

2014

130. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Nitrification inhibitors are particularly beneficial in sandy soils under heavy rainfall or irrigation.
Reason (R): They keep nitrogen in the positively charged ammonium form, which is held by the soil CEC and less susceptible to leaching than nitrate.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

131. Which of the following best explains why urease inhibitors are most effective when urea is surface-applied rather than incorporated?
(A) Surface urea is highly prone to volatilization, which is mitigated.
(B) Soil incorporation naturally protects urease inhibitors from UV light.
(C) Active urease enzymes do not exist beneath the immediate soil surface.
(D) Soil incorporation chemically degrades the inhibitor immediately.

2021

132. Which specific enzyme step is blocked by the action of Nitrapyrin?
(A) Nitrite oxidoreductase in Nitrobacter
(B) Nitrogenase complex in Rhizobium
(C) Ammonia monooxygenase in Nitrosomonas
(D) Nitrate reductase enzyme in plant roots

2016

133. Identify the correct pair of inhibitor and its specific target.
(A) DCD – Ammonia monooxygenase
(B) NBPT – Nitrosomonas bacteria
(C) Nitrapyrin – Urease enzyme
(D) Neem extract – Urease enzyme

2008

134. Which adverse environmental outcome is most directly mitigated by the use of nitrification inhibitors?
(A) Phosphate runoff into nearby surface water bodies
(B) Toxic heavy metal accumulation in agricultural soils
(C) Ammonia volatilization losses into the atmosphere
(D) Nitrate leaching and nitrous oxide (N_2O) emissions

2008

135. Arrange the following fertilizer application methods in order of their typical spatial localization, from most localized (concentrated) to most uniformly distributed:
I. Broadcasting
II. Point placement (pellet application)

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III. Band placement
(A) I, III, II
(B) II, I, III
(C) II, III, I
(D) III, II, I

2008
136. What is the primary advantage of band placement of phosphorus fertilizers compared to broadcasting?
(A) It significantly expands the volume of soil that crop roots must explore.
(B) It maximizes contact with soil particles to enhance rapid nutrient fixation.
(C) It reduces soil contact, minimizing phosphorus fixation near roots.
(D) It is a much faster, less labor-intensive, and cheaper method of application.

2013
137. Foliar feeding of nutrients is most appropriate and effective under which of the following conditions?
(A) Supplying the complete nitrogen requirement for high-yielding field crops.
(B) Applying heavy bulk doses of agricultural lime to correct soil acidity.
(C) Supplying basal phosphorus and potassium directly to the soil before sowing.
(D) Correcting acute micronutrient deficiencies when root uptake is limited.

2014
138. In fertigation, which characteristic is absolutely essential for a solid fertilizer intended for use?
(A) 100% water solubility
(B) High content of insoluble impurities
(C) Formulated as large granules
(D) Contains a slow-release polymer coating

2002
139. Which two fertilizers are generally considered incompatible for simultaneous mixing in a fertigation tank due to the risk of precipitate formation?
(A) Granulated urea and potassium nitrate
(B) Calcium nitrate and diammonium phosphate
(C) Ammonium nitrate and potassium chloride
(D) Granulated urea and ammonium sulfate

2011
140. Match the specialized application methods in List I with their defining characteristics in List II.
List I: (Application Method)
P. Fertigation
Q. Foliar application
R. Pellet application
S. Band placement
List II: (Characteristic)
1. Deep placement of nitrogen in lowland rice to avoid oxidized zone
2. Application of dissolved fertilizers through irrigation systems
3. Placement of fertilizer in continuous narrow strips near the seed row
4. Spraying dilute nutrient solutions directly onto plant canopies
(A) P-2, Q-4, R-1, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

2012
141. The deep placement of urea super granules (pellet application) in flooded rice fields aims to minimize nitrogen loss by:
(A) Placing urea in the reduced zone to prevent nitrification-denitrification.
(B) Significantly increasing biological nitrogen fixation by cyanobacteria.
(C) Enhancing surface ammonia volatilization under high pH water conditions.
(D) Making the urea nutrient temporarily inaccessible to deep crop roots.

NODIA

2010
142. What is a critical limitation or risk associated with foliar feeding?
(A) High risk of nutrient leaching through the sandy soil profile.
(B) Severe compaction of soil caused by heavy spraying machinery.
(C) Leaf burn (phytotoxicity) if spray concentration is too high.
(D) Long-term tie-up of nutrients in the soil organic matter pool.

2010
143. Which application method is most suitable for a pasture or an established orchard where soil incorporation is not feasible?
(A) Band placement method
(B) Deep injection method
(C) Drill placement method
(D) Top dressing method

2012
144. Which of the following best defines the primary objective of Integrated Nutrient Management (INM)?

(A) Replacing all chemical fertilizers with organic manures to achieve organic farming.
(B) Maximizing synthetic fertilizer use to achieve the highest possible crop yields.
(C) Combining organic, inorganic, and biological sources to sustain fertility and yields.
(D) Eliminating the need for soil testing by applying standard blanket recommendations.

2009

145. In an INM system, crop residues are incorporated primarily to:
(A) Instantly supply highly available water-soluble phosphorus to crops.
(B) Enhance soil organic matter, nutrient recycling, and physical properties.
(C) Kill harmful soilborne pathogens and weed seeds through rapid heating.
(D) Temporarily suppress unnecessary biological nitrogen fixation in soil.

2023

146. Which biofertilizer is typically recommended as a component of INM for a leguminous crop like soybean?
(A) Azotobacter
(B) Azospirillum
(C) Blue-Green Algae (BGA)
(D) Bradyrhizobium

2004

147. A synergistic effect in INM is often observed when organic manures are applied alongside rock phosphate. What drives this synergy?
(A) Decomposition of organic matter releases organic acids that solubilize it.
(B) Organic manures increase soil pH, making rock phosphate much more soluble.
(C) Organic manures physically crush the rock phosphate into smaller particles.
(D) Organic matter directly fixes and concentrates atmospheric phosphorus.

2013

148. Which of the following is an example of a phosphate-solubilizing biofertilizer used in INM?
(A) Nitrosomonas
(B) Rhizobium leguminosarum
(C) Bacillus megaterium
(D) Trichoderma viride

2016

149. Identify the INCORRECT statement regarding the components of Integrated Nutrient Management.
(A) Biofertilizers directly add physical NPK mass to the soil.
(B) FYM provides secondary and micronutrients in addition to NPK.
(C) Green manuring with Sesbania adds significant organic nitrogen.
(D) Inorganic fertilizers provide nutrients during peak crop demands.

2011

150. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Long-term INM practices lead to improved soil buffering capacity and resilience against environmental stress.
Reason (R): The continuous addition of organic matter enhances the stable humus pool and cation exchange capacity of the soil.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

151. Azolla is commonly used as a biofertilizer component in the INM of which crop ecosystem?
(A) Rainfed wheat
(B) Lowland flooded rice
(C) Arid pearl millet
(D) Greenhouse tomatoes

2021

152. What is the typical Carbon-to-Nitrogen (C:N) ratio of well-rotted Farmyard Manure (FYM), making it suitable for immediate nutrient release without severe immobilization?
(A) $>$ 100:1
(B) 60:1
(C) 15:1 to 20:1
(D) 5:1

2007

153. How is Agronomic Efficiency (AE) of a nitrogen fertilizer mathematically defined?
(A) Nutrient uptake in fertilized plot / Yield of fertilized plot
(B) Total biomass / Total nitrogen applied
(C) (Nutrient uptake in fertilized plot - Nutrient uptake in control) / Amount of fertilizer applied
(D) (Yield of fertilized plot - Yield of control plot) / Amount of fertilizer applied

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2013

154. Which metric evaluates the ability of a plant to translate a unit of absorbed nutrient into economic yield?
(A) Physiological Efficiency (PE)
(B) Apparent Recovery Efficiency (ARE)
(C) Agronomic Efficiency (AE)
(D) Partial Factor Productivity (PFP)

2018

155. Arrange the following steps to accurately calculate the Apparent Recovery Efficiency (ARE) of a fertilizer:
I. Subtract the nutrient uptake of the control plot from the fertilized plot.
II. Determine the total nutrient uptake in the control plot.
III. Determine the total nutrient uptake in the fertilized plot.
IV. Divide the difference by the amount of nutrient applied and multiply by 100.
Select the correct sequence from the options below:
(A) III, I, II, IV
(B) II, III, I, IV
(C) I, II, III, IV
(D) II, I, III, IV

2011

156. If a farmer applies 100 kg N/ha, resulting in a crop uptake of 80 kg N/ha, whereas the control plot with 0 kg N/ha had a crop uptake of 30 kg N/ha. What is the Apparent Recovery Efficiency of the applied nitrogen?
(A) 30%
(B) 50%
(C) 80%
(D) 110%

2006

157. Which factor most commonly causes low Apparent Recovery Efficiency of nitrogen fertilizers in lowland rice?
(A) High volatilization, denitrification, and leaching losses.
(B) Low photosynthetic rates under standard tropical conditions.
(C) High organic matter content restricting nutrient mobility.
(D) Luxury consumption of potassium by the growing rice crop.

2011

158. Physiological Efficiency is expressed mathematically as:
(A) $\frac{\Delta U}{\Delta F}$ (Increase in uptake per unit of fertilizer applied)
(B) $\frac{Y}{F}$ (Total yield per unit of fertilizer applied)
(C) $\frac{\Delta Y}{\Delta U}$ (Increase in yield per unit increase in nutrient uptake)
(D) $\frac{\Delta Y}{\Delta F}$ (Increase in yield per unit of fertilizer applied)

NODIA

2004

159. An increase in the Agronomic Efficiency of a fertilizer can be achieved by:
(A) Applying the fertilizer at the incorrect crop growth stage.
(B) Increasing the rate of application to potential toxicity levels.
(C) Broadcasting urea on wet soil surfaces without incorporation.
(D) Synchronizing fertilizer application with peak crop demand.

2002

160. Match the efficiency parameters in List I with their respective units or expressions in List II.
List I: (Efficiency Parameter)
P. Agronomic Efficiency (AE)
Q. Apparent Recovery Efficiency (ARE)
R. Physiological Efficiency (PE)
S. Partial Factor Productivity (PFP)
List II: (Unit/Expression)
1. Percentage (%)
2. kg crop yield increase per kg nutrient absorbed
3. kg crop yield increase per kg nutrient applied
4. kg total crop yield per kg nutrient applied
(A) P-3, Q-1, R-2, S-4
(B) P-2, Q-1, R-3, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

2022

161. Identify the correct statement regarding fertilizer efficiencies.
(A) Agronomic efficiency is always higher than Apparent Recovery Efficiency.
(B) Agronomic efficiency is the product of ARE and PE ($AE = ARE \times PE$).
(C) Recovery efficiency of phosphorus is typically higher than that of nitrogen.
(D) Physiological efficiency strictly evaluates fertilizer losses in the soil.

2018

162. When evaluating fertilizer schedules in cropping systems, the "residual effect" refers to:

(A) The immediate crop yield response observed in the current season's crop.
(B) The toxic buildup of chemical salts within the active root zone profile.
(C) The percentage of applied fertilizer nutrients lost through surface runoff.
(D) The nutrient benefit obtained by the succeeding crop from previous application.

2015
163. Which nutrient is most noted for its strong residual effects in cropping systems, often requiring application to only one crop in the sequence?
(A) Phosphorus
(B) Nitrogen
(C) Potassium
(D) Sulfur

2024
164. In a Rice-Wheat cropping system, it is generally recommended to apply Farmyard Manure (FYM) to which crop to maximize system efficiency?
(A) Wheat
(B) Both equally in split doses
(C) Rice
(D) Neither, FYM should only be used in legumes

2025
165. The "cumulative effect" of fertilizers in a long-term cropping system refers to:
(A) Gradual changes in soil fertility over successive cycles from repeated application.
(B) Immediate leaf burn on seedlings when too much fertilizer is placed in the furrow.
(C) Synergistic chemical interaction between two simultaneously applied fertilizers.
(D) Total volume of irrigation water required to fully dissolve applied fertilizers.

2008
166. Consider the following statements about fertilizer scheduling in cropping systems:
I. Legumes in a crop rotation generally increase the nitrogen requirement of the succeeding cereal crop.
II. Phosphorus application to wheat shows a significant residual effect on succeeding rice.
III. Deep-rooted crops can utilize leached nutrients from shallower zones, improving system efficiency.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2021
167. Why are direct nutrient effects usually evaluated over single seasons, while cumulative effects require long-term experiments?
(A) Direct response effects are only visible under controlled laboratory settings.
(B) Soil carbon and nutrient pool changes occur very slowly over many years.`
(C) Short-term research trials are too expensive to maintain for long periods.
(D) Cumulative carryover effects are far less agrononically important than direct ones.

2025
168. In an intensive Maize-Potato-Wheat cropping system, which nutrient schedule strategy represents a "system-based" approach?
(A) Applying independent blanket recommendations to each crop with no residue credit.
(B) Applying all required fertilizer nutrients for the entire cycle to the maize crop.
(C) Reducing subsequent crop fertilizer doses based on heavy potato carryover.
(D) Omitting nitrogen application entirely because three distinct crops are grown.

2017
169. Identify the INCORRECT statement regarding nutrient management in cropping systems.
(A) Crop residues from cereals have a high C:N ratio and can temporarily immobilize soil nitrogen.
(B) The residual effect of applied nitrogen is generally much lower than that of phosphorus.
(C) Potassium often shows significant cumulative depletion in intensive cereal-cereal rotations if crop residues are entirely removed.
(D) Intercropping a legume with a cereal completely eliminates the cereal's need for synthetic nitrogen.

2021
170. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Fertilizer recommendations for a crop in a rotation often differ from recommendations for the same crop grown as a monoculture.
Reason (R): The preceding crop alters the soil nutrient status through residual nutrients,

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organic matter addition, and altered soil biology.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

171. Site-Specific Nutrient Management (SSNM) diverges from traditional blanket recommendations primarily by:
(A) Recommending identical, standardized fertilizer doses across broad agricultural districts.
(B) Matching nutrient application to field-specific variability and crop demand.
(C) Restricting and banning the use of all inorganic synthetic fertilizers entirely.
(D) Relying entirely on pre-plant laboratory soil testing with zero in-season changes.

2010

172. The "nutrient omission plot technique" used in developing SSNM recommendations involves:
(A) Applying zero fertilizer nutrients to the entire experimental field area.
(B) Withholding one target nutrient while applying all other nutrients adequately.
(C) Omitting essential micronutrients while applying excessive macronutrient doses.
(D) Removing the entire topsoil layer to measure subsoil nutrient contribution.

2005

173. What is the primary purpose of using a Leaf Color Chart (LCC) in rice and wheat cultivation?
(A) To estimate leaf nitrogen status visually for real-time topdressing.
(B) To diagnose severe phosphorus deficiency in early crop vegetative stages.
(C) To determine the precise maturity and optimal time for grain harvesting.
(D) To detect and identify visual fungal pathogen infections in the canopy.

2016

174. Optical crop sensors, such as the GreenSeeker, operate by measuring plant reflectance in which specific regions of the electromagnetic spectrum to calculate NDVI?
(A) Ultraviolet and Blue
(B) Green and Far-Infrared
(C) Red and Near-Infrared (NIR)
(D) X-ray and Microwave

2017

175. Consider the following statements about SSNM:
I. SSNM relies heavily on the concept of feeding the crop dynamically as its needs change.
II. NDVI sensors estimate crop biomass and nitrogen status simultaneously.
III. The nutrient omission technique calculates the indigenous nutrient supply of the soil.
IV. LCC is an expensive, computerized tool requiring extensive technical training.
V. SSNM typically increases nitrogen use efficiency compared to blanket recommendations.
Which of the above statement(s) is/are correct?
(A) I, II, III, V
(B) I, III, IV, V
(C) II, III, IV, V
(D) I, II, IV, V

2025

176. Normalized Difference Vegetation Index (NDVI) is mathematically calculated using the reflectance values as:
(A) $\frac{\text{NIR} + \text{Red}}{\text{NIR} - \text{Red}}$
(B) $\frac{\text{Green} - \text{Red}}{\text{Green} + \text{Red}}$
(C) $\frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$
(D) $\frac{\text{NIR} - \text{Blue}}{\text{NIR} + \text{Blue}}$

2021

177. When using the nutrient omission plot technique, if the grain yield in the fully fertilized plot is 8 t/ha and the yield in the -P (phosphorus omitted) plot is 5 t/ha, what does the yield difference represent?
(A) The toxic physiological effect of applied phosphorus fertilizer on crop yield.
(B) The yield response to applied phosphorus, representing field requirement.
(C) The agronomic nitrogen use efficiency and recovery efficiency of the crop.
(D) The inherent phosphorus toxicity and mineral imbalance within the root zone.

2004

178. What is the main advantage of active optical sensors (like GreenSeeker) over passive optical sensors for crop monitoring?
(A) They scan and measure much deeper into the soil profile to find nutrients.
(B) They are significantly cheaper to construct and operate without batteries.

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(C) They accurately measure soil moisture content in addition to leaf nitrogen.
(D) They use an internal light source, permitting use under any ambient light.

2021
179. Identify the INCORRECT statement regarding the Leaf Color Chart (LCC).
(A) It provides a precise, quantitative measure of tissue nitrate.
(B) It functions as a simple, inexpensive visual diagnostic tool in fields.
(C) Readings must be taken under body shade to avoid direct sunlight glare.
(D) The topmost fully expanded leaf is chosen for standard measurements.

2015
180. The Targeted Yield Concept for fertilizer recommendation was primarily developed in India by:
(A) M.S. Swaminathan
(B) J.W. Liebig
(C) B.V. Ramamoorthy
(D) E. Truog

2017
181. Which equation forms the basis of the Soil Test Crop Response (STCR) targeted yield approach?
(A) $F = \frac{NR \times T - CS \times STV}{CF}$
(B) $\log(A - y) = \log A - cx$
(C) $Y = a + bX + cX^2$
(D) $F = \frac{STV \times CF}{NR}$

Where F = Fertilizer dose, NR = Nutrient Requirement, T = Yield Target, CS = Contribution from Soil, STV = Soil Test Value, CF = Contribution from Fertilizer.

2018
182. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): The STCR targeted yield approach assumes a linear relationship between crop yield and nutrient uptake.
Reason (R): For a specific crop and variety, a definite amount of nutrient is required to produce one unit of economic yield.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001
183. In the Mitscherlich-Bray approach to quantitative fertilizer recommendation, Bray modified Mitscherlich's equation to account for:
(A) The total organic matter content and humic substances of the soil.
(B) Nutrients from both native soil supply and applied fertilizer.
(C) The specific genetic potential of modern high-yielding crop varieties.
(D) The severe seasonal moisture deficit experienced in rainfed farming.

2002
184. To develop STCR equations, which three fundamental parameters must be calculated from field experiments?
(A) Soil pH, cation exchange capacity, and percentage base saturation.
(B) Bulk density, particle density, and total soil macroporosity.
(C) Nutrient requirement, soil efficiency, and fertilizer efficiency.
(D) Agronomic efficiency, physiological efficiency, and economic efficiency.

2014
185. Consider the following quantitative approaches:
I. The Targeted Yield Concept accounts for the nutrient contribution from both soil and fertilizer.
II. The Mitscherlich-Bray equation cannot predict crop yield responses.
III. STCR equations can be adjusted for the application of organic manures.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2013
186. Match the quantitative approaches or concepts in List I with their defining characteristics or authors in List II.
List I: (Approach/Concept)
P. STCR Targeted Yield
Q. Law of the Minimum
R. Law of Diminishing Returns
S. Nutrient Mobility Concept
List II: (Author)
1. B.V. Ramamoorthy

NODIA

2. J. von Liebig
3. E. Mitscherlich
4. R.H. Bray

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-3, R-2, S-1

2023

187. What happens in the STCR model if the targeted yield is set unrealistically high for the given agro-climatic conditions?
(A) The model mathematically recalibrates and corrects the target automatically.
(B) The calculated dose becomes excessively high, causing economic and eco damage.
(C) The internal soil contribution parameter drops to zero in response.
(D) The growing crop undergoes luxury nutrient consumption to reach the target.

2021

188. Methemoglobinemia, or "blue baby syndrome", is a human health risk directly associated with the contamination of drinking water by which agricultural pollutant?
(A) Phosphate
(B) Nitrate
(C) Zinc
(D) Sulfate

2023

189. Which environmental phenomenon is primarily caused by the runoff of excess agricultural phosphorus into freshwater lakes and streams?
(A) Eutrophication
(B) Acid rain
(C) Ozone depletion
(D) Global warming
(A) Eutrophication
(B) Acid rain
(C) Ozone depletion
(D) Global warming

2001

190. Agricultural soils are a major source of which potent greenhouse gas, primarily generated as a byproduct of denitrification and nitrification?
(A) Carbon monoxide (CO)
(B) Methane (CH_4)
(C) Nitrous oxide (N_2O)
(D) Chlorofluorocarbons (CFCs)

2005

191. Nitrate leaching is most severe under which of the following combinations of soil and climatic conditions?
(A) Heavy clay soils under arid or semi-arid climates.
(B) Fine silt loam soils under freezing winter conditions.
(C) Acidic peat soils located in waterlogged wetland zones.
(D) Sandy soils under heavy rainfall or excessive irrigation.

2023

192. Eutrophication leads to fish kills in aquatic ecosystems primarily due to:
(A) Direct chemical toxicity of soluble phosphorus compounds to fish gills.
(B) Increased acidity of the water column from rapid nitrate accumulation.
(C) Oxygen depletion caused by decomposition of massive algal blooms.
(D) Physical blockage of critical sunlight by suspended fertilizer particles.

2009

193. Which practice is most effective in mitigating the emission of agricultural greenhouse gases like nitrous oxide (N_2O) from fertilized fields?
(A) Applying all nitrogen fertilizer in a single massive dose at planting.
(B) Using nitrification inhibitors and optimizing application rates.
(C) Leaving agricultural fields bare during the off-season to dry out.
(D) Maximizing the use of continuous flood irrigation in all seasons.

2005

194. Identify the INCORRECT statement regarding the environmental impacts of fertilizers.
(A) Ammonia volatilization contributes to the formation of fine particulate matter (PM2.5) in the atmosphere.
(B) High nitrate levels in drinking water are toxic to infants because nitrite binds to hemoglobin.
(C) Phosphorus is highly immobile in soil, so its primary transport mechanism to water bodies is via soil erosion and surface runoff.
(D) Excess potassium fertilizer is the primary cause of coastal dead zones.

2011

195. Consider the following statements about fertilizer environmental impacts:

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I. Nitrous oxide has a global warming potential nearly 300 times that of carbon dioxide.
II. Nitrate is an anion and is repelled by the negative charge of clay particles, making it prone to leaching.
III. Eutrophication strictly occurs in marine environments, not freshwater.

Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2011

196. The continuous application of phosphatic fertilizers, specifically single super phosphate and rock phosphate, is known to slowly contaminate agricultural soils with which toxic heavy metal?
(A) Lead (Pb)
(B) Mercury (Hg)
(C) Cadmium (Cd)
(D) Arsenic (As)

2005

197. Peri-urban agricultural soils are particularly vulnerable to heavy metal contamination primarily due to:
(A) Extensive irrigation with untreated municipal and industrial wastewater.
(B) Natural weathering processes of highly mineralized bedrock near cities.
(C) High decomposition rates of organic matter caused by urban microclimates.
(D) Excessively high and continuous application of nitrogenous fertilizers.

2004

198. Which heavy metal is famously associated with the "Itai-itai" disease, characterized by severe bone softening and kidney failure, due to its accumulation in rice grains?
(A) Lead (Pb)
(B) Chromium (Cr)
(C) Arsenic (As)
(D) Cadmium (Cd)

2021

199. Arsenic contamination in groundwater and agricultural soils, heavily affecting rice cultivation, is a massive biogeochemical disaster primarily located in which region?
(A) The Great Plains region of North America
(B) The Bengal Delta plain of South Asia
(C) The tropical rainforests of the Amazon
(D) The arid zones of the Sahara Desert

2019

200. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Hexavalent chromium [Cr(VI)] is significantly more toxic and mobile in soils than trivalent chromium [Cr(III)].
Reason (R): Cr(VI) exists as an anion (e.g., chromate) that is weakly adsorbed by soil components, whereas Cr(III) readily precipitates as insoluble hydroxides.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

201. Match the heavy metals in List I with their primary agricultural or anthropogenic sources in List II.
List I: (Heavy Metal)
P. Cadmium (Cd)
Q. Lead (Pb)
R. Arsenic (As)
S. Chromium (Cr)
List II: (Source)
1. Tannery effluent wastewater
2. Historically used leaded gasoline exhaust settling on fields
3. Contaminated groundwater used for irrigation
4. Impurities in rock phosphate fertilizers
(A) P-4, Q-2, R-3, S-1
(B) P-3, Q-1, R-4, S-2
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-3, R-2, S-1

NODIA

2008

202. What is the primary mechanism by which lead (Pb) is immobilized in most agricultural soils?
(A) Complexation with organic matter and precipitation as insoluble salts.
(B) Rapid volatilization into the atmosphere as volatile organometallic gases.
(C) Rapid translocation and hyperaccumulation throughout all cereal plant tissues.
(D) Complete microbial degradation in the rhizosphere to harmless elemental lead.

2022

203. Identify the INCORRECT statement regarding the toxicity mechanisms of heavy metals in plants.

(A) Heavy metals can induce oxidative stress by generating reactive oxygen species.
(B) They promote chlorophyll synthesis, leading to hyper-photosynthesis.
(C) They can displace essential metal ions from the active sites of critical enzymes.
(D) They can cause direct, permanent structural damage to plant cell membranes.

2005

204. Phytoremediation using hyperaccumulator plants to absorb heavy metals from the soil and transport them into the harvestable above-ground biomass is specifically termed:
(A) Phytostabilization
(B) Phytoextraction
(C) Phytovolatilization
(D) Rhizofiltration

2022

205. How does phytostabilization differ from phytoextraction?
(A) Phytostabilization immobilizes contaminants, while phytoextraction removes them via uptake.
(B) Phytostabilization converts metals into volatile gases, while phytoextraction stores them in roots.
(C) Phytostabilization uses chemical solvents, whereas phytoextraction relies purely on microbes.
(D) Phytostabilization is a chemical technique, while phytoextraction is purely biological.

2010

206. The application of chemical amendments like agricultural lime to heavy-metal contaminated soils primarily achieves remediation by:
(A) Chelating the heavy metals to make them highly soluble and prone to deep leaching.
(B) Providing an abundant organic carbon source to stimulate indigenous degrading bacteria.
(C) Raising soil pH to precipitate metals as insoluble compounds, reducing bioavailability.
(D) Physically binding the toxic metals into a synthetic, non-biodegradable solid polymer.

2017

207. Which hyperaccumulator plant species is widely studied for its exceptional ability to extract arsenic from contaminated soils and water?
(A) Brassica juncea (Indian mustard)
(B) Thlaspi caerulescens (Alpine pennycress)
(C) Helianthus annuus (Sunflower)
(D) Pteris vittata (Chinese brake fern)

2016

208. Consider the following remediation strategies:
I. Applying biochar to contaminated soils binds heavy metals and reduces their bioavailability.
II. Phytoextraction is highly effective for rapidly cleaning up deeply contaminated groundwater aquifers.
III. Adding organic matter generally decreases the mobility of metals like lead and copper.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2014

209. Bioremediation of heavy metals by soil microorganisms primarily involves:
(A) Completely destroying and breaking down heavy metal atoms into carbon.
(B) Altering metal oxidation states to reduce toxicity and mobility.
(C) Using specialized bacteria to physically carry metals out of root zones.
(D) Significantly increasing localized soil temperature to vaporize metals.

2008

210. Which chemical amendment is often applied in situ to contaminated soils to transform highly soluble and toxic lead (Pb) into the highly insoluble and stable mineral pyromorphite?
(A) Elemental sulfur powder
(B) Sodium chloride salt
(C) Ammonium nitrate salt
(D) Phosphatic amendments

****

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ANSWERS

1. (B) Liebig's Law of the Minimum
Crop yields are constrained by the essential nutrient that is least available relative to the plant needs. When this deficient nutrient is supplied, growth improves until another essential element becomes the new limiting factor. This fundamental agronomic principle emphasizes balancing fertilizer applications to address the most severe nutritional deficiencies first.

2. (D) Yield increase per unit of added nutrient declines as the maximum yield is approached.
Crop yield responses to added nutrients follow a law of diminishing returns where successive increments of fertilizer produce smaller yield increases. As plant growth approaches its maximum potential yield, the efficiency of each added nutrient unit declines systematically. This relationship helps determine economically optimal fertilizer application rates in diverse crop production systems.

3. (A) They are primarily extracted from the entire volume of soil water within the root zone.
Mobile nutrients dissolve fully in soil water and move freely through the root zone via mass flow. Plants extract these highly soluble ions from the entire volume of water-saturated soil surrounding their roots. Consequently, the availability of highly mobile nutrients is determined by the total root zone volume rather than localized root surface contact.

4. (C) $\log(A - y) = \log A - cx$
This mathematical expression represents the logarithmic relationship between fertilizer application and crop yield response. The formula shows that the rate of yield increase diminishes as the maximum potential yield is approached. By calculating the constant value, agronomists can estimate potential crop yields and optimize nutrient management strategies under specific field conditions.

5. (A) Roger Bray
The differentiation between total soil nutrient content and actual plant-available nutrients marked a significant advancement in agronomy. This concept established that chemical extractants must target only the soluble and exchangeable nutrient fractions to predict crop response accurately. Consequently, modern soil testing procedures are designed to estimate the biologically active pool of nutrients.

NODIA

6. (D) It fails to consider nutrient interactions and substitution as soil fertility improves.
The law of the minimum assumes a strict linear relationship where only one nutrient limits growth at a time. This simple model applies well to highly depleted soils where a single deficiency dominates. However, it fails in fertile soils where complex synergistic or antagonistic interactions and nutrient substitutions significantly influence plant growth dynamics.

7. (B) By root interception and diffusion over relatively short distances.
Immobile nutrients react strongly with soil particles and do not move freely in solution. Consequently, plants must acquire these elements through direct root interception as roots grow into new soil volume. Short-distance diffusion also delivers these highly restricted ions to the root surface, making root system architecture critical for their absorption.

8. (C) It assumes the proportionality constant (c) remains constant under all conditions.
The original mathematical model assumes that the proportionality factor remains constant across different crops, soils, and environments. In actual field conditions, this factor varies significantly due to soil physical properties, climate, and management practices. This variable behavior limits the universal applicability of the equation without site-specific calibrations and modifications.

9. (D) Mitscherlich's equation perfectly predicts yield depressions caused by excessive fertilizer application.
Mathematical models of diminishing returns describe yield plateaus at high nutrient levels but do not account for toxicities. Excessive fertilizer applications often cause severe physiological yield depressions due to osmotic stress, nutrient imbalances, or toxicity. Specialized quadratic

or non-linear models are required to accurately predict these toxic decline phases in crops.

10. (A) Both A and R are true and R is the correct explanation of A.
Essential nutrients are universally required by all higher plants to complete their life cycles. In contrast, functional nutrients promote growth in specific plant species or partially substitute for essential elements under certain conditions. Sodium is not universally essential but acts functionally in halophytes and can partially replace potassium in osmotic regulation.

11. (B) Arnon and Stout
The formal criteria defining whether a chemical element is essential for plant growth were established in nineteen thirty-nine. These principles require that the plant cannot complete its life cycle without the element, the deficiency is specific, and the element is directly involved in metabolism. This framework remains the basis for modern plant nutrition.

12. (B) The element significantly increases crop yield under all environmental conditions.
Increasing crop yields under all environmental conditions is not a requirement for determining nutrient essentiality. An element is essential only if its absence prevents the completion of the plant life cycle, its function is non-substitutable, and it acts directly in metabolic processes. Many essential elements fail to increase yields under highly optimal soil conditions.

13. (A) Silicon, Cobalt, Sodium, Vanadium
Beneficial elements stimulate growth, enhance stress tolerance, or improve metabolic efficiency in certain plant species but are not universally required to complete their life cycles. Silicon, cobalt, sodium, and vanadium represent classic beneficial nutrients. These elements provide structural strength, assist in nitrogen fixation, or optimize enzymatic activities under specific environmental conditions.

14. (C) A functional element promotes growth or substitutes for another, but is not strictly required to complete the life cycle.
Essential elements are universally required by all plants to complete their vegetative and reproductive stages. Functional elements, however, are non-essential nutrients that stimulate growth, enhance metabolic efficiency, or substitute for essential nutrients in certain species. This classification helps agronomists understand how non-essential minerals can optimize crop yields and stress tolerance.

15. (C) I and III
Essential elements must participate directly in plant metabolic processes and cannot be replaced by other nutrients. While beneficial elements can improve growth, they are incapable of completely substituting for essential elements in plant survival. Nickel is the most recently recognized essential micronutrient, required specifically for the activation of the urease enzyme.

16. (C) Nickel
Plants require specific micronutrients to catalyze key metabolic reactions. This particular transition metal serves as the mandatory cofactor for the enzyme urease, which hydrolyzes urea into ammonia and carbon dioxide. Without this element, toxic urea accumulates in leaf tissues, causing necrotic leaf tips and severely disrupting overall nitrogen metabolism within the plant.

17. (B) Silicon – Beneficial element
Silicon is classified as a beneficial element rather than an essential nutrient because most plants can complete their life cycles without it. However, it deposits in cell walls, providing physical rigidity, lodging resistance, and protection against pests. This beneficial function is particularly vital for agronomic crops like rice, sugarcane, and other grasses.

18. (D) It is required in such minute quantities that inducing deficiency is extremely difficult.
Plants require certain micronutrients in extremely minute concentrations, making scientific detection highly challenging. This element is needed in such trace amounts that standard laboratory purification techniques could not easily remove it from growth media. Advances in highly refined nutrient purification methods ultimately allowed researchers to induce and verify its specific deficiency symptoms.

19. (A) Mass flow
Soluble ions dissolved in the soil solution move toward plant roots along with the convective flow of water. This transport mechanism is driven entirely by plant transpiration and water uptake. Soluble anions like nitrate do not bind to

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soil surfaces, allowing them to travel rapidly and efficiently through this mass water movement.

20. (B) P-3, Q-1, R-2, S-4
Transpirational water uptake drives mass flow, delivering soluble nutrients to roots. Concentration gradients drive diffusion, which is critical for less mobile nutrients. Root interception occurs as growing roots physically explore new soil volume and make direct contact with nutrients. Ion exchange involves the reversible displacement of adsorbed ions on clay surfaces.

21. (A) Phosphorus
Phosphate ions react strongly with soil minerals, keeping their concentration in the soil solution extremely low. Because mass flow cannot supply sufficient quantities, plants rely heavily on diffusion to meet their needs. This process moves ions along a concentration gradient from the surrounding soil to the depleted zone near the root surface.

22. (D) It reduces the water-filled pore space, restricting phosphorus diffusion.
Nutrient diffusion occurs through water films surrounding soil particles. When soil moisture declines, the thickness of these water films decreases, and the pathway becomes highly tortuous. This physical change severely restricts the diffusion of immobile nutrients like phosphorus, reducing their availability to plant roots even if total soil nutrient levels are adequate.

23. (B) Roots grow into new soil volume, directly contacting and absorbing available nutrients.
Plants actively expand their root systems to explore new volumes of soil. As root tips grow and elongate, they make direct physical contact with nutrients adsorbed on soil colloids. This process allows the plant to absorb essential elements directly from the soil matrix without relying on long-distance movement through the soil solution.

24. (A) Diffusion, Mass flow, Root interception
Diffusion is the primary mechanism delivering potassium to plant roots, accounting for the vast majority of its uptake in agricultural soils. Mass flow contributes a much smaller portion, while direct root interception provides only a minimal percentage. Maintaining adequate soil moisture is therefore vital to sustain the diffusion pathways necessary for potassium nutrition.

25. (C) III only
Root interception accounts for only a minor fraction of overall nutrient uptake, typically supplying less than two percent of total nitrogen requirements. Nitrogen is highly soluble and mobile, meaning the vast majority of its uptake occurs via transpirational mass flow. Diffusion and mass flow dominate the delivery of highly soluble macronutrients to plant roots.

26. (A) High CEC soils maintain a larger reserve of exchangeable cations to replenish the soil solution.
Cation exchange capacity represents the total capacity of a soil to hold exchangeable positive ions. Soils with high exchange capacity serve as a massive nutrient reservoir, buffering the soil solution against rapid depletion. These soils hold essential cations tightly enough to prevent leaching while keeping them accessible for plant root uptake.

27. (B) Fick's First Law
The movement of molecules or ions along a concentration gradient is described by a fundamental physical relationship. This law states that the flux of a substance is proportional to its concentration gradient. In soil science, this mathematical framework explains how immobile nutrients diffuse through water-filled pores toward the depleted zone surrounding plant roots.

NODIA

28. (B) A sub-critical nutrient deficiency that reduces yield without visible symptoms.
Plants often suffer from moderate nutrient deficiencies that impair physiological processes and reduce yields without producing any visible leaf symptoms. This sub-clinical deficiency state can only be detected through chemical tissue analysis or soil testing. Addressing this unapparent nutritional stress is critical for optimizing crop yields and agricultural profitability.

29. (A) The phase where both plant yield and tissue nutrient concentration increase simultaneously.
In this specific phase of the yield-response curve, nutrient additions stimulate both plant growth and internal tissue nutrient concentrations. The plant is overcoming a moderate deficiency,

so the absorbed nutrients are used for both increasing biomass and raising tissue levels. This dual response indicates transition from severe deficiency toward sufficiency.

30. (B) Both A and R are true but R is not the correct explanation of A.
Luxury consumption occurs when plants continue absorbing nutrients beyond the level required for maximum growth, resulting in higher tissue concentrations without any corresponding increase in crop yield. This phenomenon is highly common with potassium. Both statements are accurate, but the potassium example serves as an application rather than a causal explanation.

31. (D) The concentration in plant tissue associated with a 10% reduction from maximum yield.
The critical nutrient concentration is defined as the specific concentration of an element in a particular plant part at a defined growth stage associated with a ten percent reduction in maximum yield. Below this threshold, the plant is considered deficient, and applying fertilizer will likely result in a significant yield increase.

32. (C) Yield increases with nutrient addition while tissue concentration remains constant.
Under extreme nutrient deficiency, any added nutrient is immediately and entirely utilized by the plant to produce vegetative biomass. As a result, the total crop yield increases significantly while the internal tissue concentration of that nutrient remains constant at its absolute minimum level. This phase represents severe, growth-limiting nutritional stress.

33. (B) Fertilizer is applied and luxury uptake occurs without increasing total crop yield.
Applying excess fertilizer can lead to luxury consumption, where plants absorb nutrients without producing any additional crop yield. This over-application represents a direct financial loss for farmers, as the cost of the extra fertilizer does not generate any increased economic return. It highlights the importance of using soil tests to optimize applications.

34. (D) They are constant for a given crop species regardless of the plant part sampled.
Critical nutrient concentrations are highly dynamic and vary significantly based on the specific plant organ sampled and its physiological age. Younger leaves often maintain different nutrient levels compared to older leaves. Consequently, diagnostic tissue analysis requires strict standardization of both the plant part and the growth stage to ensure accurate results.

35. (D) I, II and III
The yield-response relationship contains three distinct nutritional zones. In the minimum percentage phase, yield increases with constant tissue concentration. The poverty adjustment phase shows simultaneous increases in yield and tissue concentration. Finally, the luxury consumption phase is characterized by rising tissue concentrations with no further increases in crop yield.

36. (C) Active vegetative growth or just prior to flowering.
Plant tissue analysis is most effective when conducted during active vegetative growth or just prior to flowering. During these physiological stages, nutrient demand is high, and critical concentrations are well-established. Sampling at this time allows agronomists to diagnose deficiencies early enough to apply corrective mid-season fertilizers and protect potential crop yields.

37. (B) Magnesium
This essential divalent cation acts as the central coordinating metal atom in the porphyrin ring of the chlorophyll molecule. Without this nutrient, plants cannot synthesize chlorophyll, leading to a complete loss of green coloration. This structural role makes the element absolutely critical for capturing light energy and driving photosynthesis.

38. (D) Highly mobile; interveinal chlorosis on older leaves.
This macronutrient is highly mobile within plant vascular systems, allowing it to be easily translocated from older tissues to developing sinks. When a deficiency occurs, the plant mobilizes the nutrient out of older leaves to support new growth. This leads to characteristic interveinal chlorosis appearing first on the lower, older leaves.

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39. (B) It regulates stomatal movement, cell osmoregulation, and enzyme activation.
This essential cation does not form structural organic compounds in plants but remains dissolved in cellular fluids. It plays a primary role

in maintaining cell turgor pressure, regulating stomatal opening and closing, and activating over sixty enzymes. It also balances organic anions and facilitates the translocation of sugars and starches.

40. (A) P-2, Q-1, R-4, S-3
Phosphorus deficiency causes dark green foliage and distinct purpling on older leaves. Potassium deficiency leads to marginal chlorosis and firing on older leaf edges. Calcium deficiency causes the death of terminal buds and blossom-end rot in fruits. Sulfur deficiency is characterized by uniform chlorosis developing first on the younger leaves.

41. (D) Sulfur is relatively immobile and cannot be easily redistributed from older to younger tissues.
Sulfur is relatively immobile within plant tissues because it is incorporated into structural proteins. Once deposited, it cannot be easily remobilized or translocated from older leaves to support new growth. Consequently, when soil sulfur supplies are inadequate, the symptoms of deficiency appear first as uniform chlorosis on the youngest, developing leaves.

42. (A) Calcium
This secondary macronutrient is essential for maintaining the structural integrity of plant tissues. It binds with pectin to form calcium pectate, which is a major constituent of the middle lamella in plant cell walls. This compound acts as a physical cement, stabilizing cell walls and regulating membrane permeability throughout the plant.

43. (B) Nitrogen is highly mobile and is translocated from older to newer plant tissues.
Nitrogen is highly mobile within plants and can be easily redistributed through the phloem. When soil nitrogen is deficient, the plant degrades proteins and chlorophyll in older leaves to translocate nitrogen to the actively growing shoot tips. This physiological redistribution causes uniform yellowing, or chlorosis, to appear first on older leaves.

44. (B) Calcium – Stomatal regulation and osmoregulation
Calcium does not serve as the primary osmotic agent for stomatal regulation or cellular osmoregulation. Those vital physiological functions are driven almost entirely by potassium ions. Calcium acts primarily as a structural component of cell walls, a second messenger in cellular signaling pathways, and an activator for specific metabolic enzymes.

45. (A) I and III
Nitrogen, phosphorus, potassium, and magnesium are highly mobile within plant tissues, meaning their deficiency symptoms appear first on older leaves. In contrast, calcium and boron are highly immobile, so their deficiencies manifest at the growing tips. Sulfur is also relatively immobile, with deficiency symptoms typically appearing first on younger leaves.

46. (C) Indole-3-acetic acid (Auxin)
Zinc is an essential micronutrient involved in several enzymatic systems. It is directly required for the synthesis of tryptophan, which is the amino acid precursor of indole-three-acetic acid, the primary plant auxin. A deficiency in zinc reduces auxin levels, leading to severely shortened internodes and a clustered leaf growth pattern known as rosetting.

47. (D) Zinc
This famous physiological disorder in rice crops is characterized by the appearance of rusty brown spots on leaves and stunted plant growth. It is caused by a severe deficiency of zinc, particularly in calcareous, waterlogged, or heavily fertilized soils. Correcting this deficiency with zinc sulfate applications restored normal growth and yield.

48. (C) Molybdenum
Cauliflower plants require a specific micronutrient to function as a cofactor for the nitrate reductase enzyme. When this element is deficient, nitrate accumulates in the tissues, and normal leaf blade development is severely disrupted. This leads to thin, distorted, thread-like leaves, a characteristic physiological disorder commonly referred to as whiptail.

49. (B) Interveinal chlorosis on younger leaves with green veins.
Iron is required for chlorophyll synthesis and electron transport, but it is highly immobile in plant tissues. Because it cannot be translocated from older leaves, deficiency symptoms appear first on new growth. This manifests as a striking interveinal chlorosis on younger leaves, where the leaf veins remain green while the surrounding tissue turns yellow.

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50. (A) Both A and R are true and R is the correct explanation of A.
Unlike most other micronutrients, the availability of molybdenum is strongly dependent on soil pH and decreases significantly in highly acidic soils. In acid environments, molybdenum adsorbs tightly to iron and aluminum oxides, making it unavailable for plant uptake. Consequently, molybdenum deficiency is highly common and severe in acidic soils.

51. (A) Sunflower
This oilseed crop is highly sensitive to boron deficiency and serves as a classic indicator plant. It has a high requirement for boron to support cell wall synthesis, pollen tube germination, and seed development. Boron deficiency in this plant leads to distorted young leaves, poor seed set, and hollow stems, providing clear visual warnings.

52. (C) Manganese
Grey speck in oats and Pahala blight in sugarcane are classic physiological disorders caused by a deficiency of manganese. This micronutrient is essential for photosynthesis, nitrogen assimilation, and enzyme activation. Soil conditions such as high pH, excessive organic matter, or over-liming reduce manganese availability, leading to these distinct visual symptoms in sensitive crops.

53. (A) It aids cell wall synthesis, sugar transport, and pollen tube growth.
This unique non-metallic micronutrient plays a fundamental role in cell wall structure and membrane integrity. It is directly involved in pectin synthesis, which strengthens cell walls, and facilitates the translocation of sugars across membranes. It is also absolutely essential for pollen tube growth, pollen germination, and successful plant fertilization processes.

54. (D) Zinc
Intensive agricultural systems and high-yielding crop varieties have greatly increased the removal of micronutrients from soils. Furthermore, the widespread shift toward high-analysis fertilizers, which contain fewer impurities, has limited the accidental replenishment of trace elements. Consequently, zinc deficiency has emerged as a major widespread nutritional limitation in many global soils.

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55. (B) I and III
Synergistic interactions occur when the combined effect of two nutrients exceeds the sum of their individual applications. Conversely, antagonistic interactions, such as high phosphorus levels inducing zinc deficiency, reduce nutrient availability. Mulder's chart visually represents both synergistic and antagonistic relationships, not just negative interactions, making it an invaluable diagnostic tool.

56. (C) Excessive phosphorus inhibits the translocation of zinc from roots to shoots.
The antagonism between phosphorus and zinc is a well-documented plant physiological phenomenon. High levels of phosphorus do not simply precipitate zinc in the soil; instead, they interfere with the internal transport and physiological utilization of zinc within the plant. This metabolic disruption restricts zinc translocation from roots to shoots, inducing deficiency symptoms.

57. (D) Nitrogen and Phosphorus
Nitrogen and phosphorus exhibit a powerful synergistic relationship in crop nutrition. Applying nitrogen stimulates root growth and increases the production of root exudates, which enhances the plant's ability to absorb phosphorus from the soil. Additionally, nitrogen uptake can alter rhizosphere pH, further increasing the solubility and availability of phosphate ions.

58. (A) Magnesium
High concentrations of potassium in the soil solution can severely inhibit the uptake of magnesium by plant roots. This antagonistic relationship occurs because both cations compete for the same absorption sites on root membranes. Consequently, excessive potassium fertilization often induces magnesium deficiency symptoms, particularly in soils with low native magnesium levels.

59. (B) Synergism
When the application of one nutrient enhances the absorption, translocation, or utilization of another nutrient, the relationship is defined as synergistic. Nitrogen applications frequently improve phosphorus uptake by stimulating root system development and increasing the synthesis of proteins required for phosphorus transport. This positive interaction optimizes fertilizer efficiency and crop performance.

60. (A) P-2, Q-1, R-3, S-4
Nitrogen applications can synergistically enhance phosphorus uptake by stimulating root growth. Excessive phosphorus applications interfere with zinc translocation, inducing zinc deficiency. High potassium levels compete directly with magnesium on root membranes, leading to magnesium deficiency. Heavy calcium applications raise soil pH and reduce the solubility and availability of boron.

61. (A) Iron, Manganese, and Zinc
Applying heavy amounts of calcitic limestone raises the soil pH, which directly reduces the solubility of several essential micronutrients. Under alkaline conditions, iron, manganese, and zinc precipitate as insoluble hydroxides or oxides, making them unavailable for plant uptake. This pH-induced reduction in solubility commonly leads to severe micronutrient deficiencies in crops.

62. (C) NH_4^+ suppressing K^+ uptake
Ammonium and potassium ions share similar hydrated ionic radii and charge characteristics. Consequently, they compete directly for the same carrier proteins and transport channels on root cell membranes during absorption. High concentrations of ammonium in the soil solution can strongly suppress potassium uptake, representing a classic example of competitive ion antagonism.

63. (D) It maps synergistic and antagonistic interactions among plant nutrients.
This diagnostic tool provides a visual map of the complex relationships between different plant nutrients. It illustrates both synergistic relationships, where one nutrient enhances another, and antagonistic relationships, where excess of one nutrient inhibits another. Agronomists use this chart to diagnose nutritional imbalances and design balanced, efficient fertilizer programs.

64. (C) It uses ratios of nutrient concentrations to diagnose nutrient balance and deficiencies.
The Diagnosis and Recommendation Integrated System is a comprehensive diagnostic method that evaluates the relative balance of nutrients in plant tissues. Rather than focusing on absolute nutrient concentrations, it calculates ratios between pairs of essential nutrients. This approach accounts for the fact that nutrient proportions are highly critical for optimal metabolism.

65. (A) I and II
Nutrient ratios in plants remain relatively stable during growth, making DRIS indices less sensitive to the physiological age of the plant compared to absolute critical limits. A calculated index value near zero indicates that the nutrient is in optimal balance. Highly negative index values indicate deficiency, while positive values indicate nutrient excess.

66. (D) DRIS indices are relatively independent of dry matter dilution and crop growth stage.
The primary advantage of this diagnostic system is its relative independence from dry matter dilution and plant growth stages. As plants age, dry matter accumulates, causing absolute nutrient concentrations to decline. Because this method uses nutrient ratios rather than absolute values, it provides reliable diagnostic results throughout most of the growing season.

67. (A) Leaf sap testing using portable electrodes or strips.
Portable ion-selective electrodes and chemical test strips allow agronomists to perform rapid, semi-quantitative measurements of dissolved nutrients in fresh plant sap. This in-field diagnostic method provides immediate results regarding current nitrate or potassium levels. It serves as an invaluable tool for making timely, real-time adjustments to fertilizer programs during the growing season.

68. (B) 90% of maximum yield
The critical limit in plant tissue testing is conventionally defined as the nutrient concentration that corresponds to ninety percent of the maximum crop yield. When tissue levels fall below this threshold, the crop is suffering from deficiency, and applying the deficient nutrient is highly likely to produce a profitable yield response.

69. (A) Because nutrient concentrations vary with physiological age and among different plant organs.
Nutrient concentrations are highly dynamic and vary significantly among different plant organs and across different stages of crop development. To ensure that tissue test results can be accurately compared against established

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reference standards, agronomists must strictly standardize both the specific plant part sampled and the exact growth stage at collection.

70. (A) Both A and R are true and R is the correct explanation of A.
Rapid plant sap tests are highly effective for manageing mid-season nitrogen applications. These tests measure the unassimilated nitrate fraction currently moving through the vascular system, rather than the total accumulated organic nitrogen. This provides a highly sensitive, real-time indicator of current soil nitrogen availability and immediate plant uptake.

71. (B) Nitrogen
In this diagnostic system, negative index values represent relative nutrient deficiencies, while positive values indicate relative excesses. The most negative index value identifies the most limiting nutrient in the plant tissue. Since nitrogen has the lowest negative index in this analysis, it is the primary nutrient limiting overall crop growth.

72. (C) It requires a large database of high-yielding reference crop populations.
Implementing this diagnostic system requires establishing reference norms from a very large database of nutrient concentrations and crop yields. These norms must represent a high-yielding subpopulation under diverse environmental conditions. Developing this comprehensive reference database is labor-intensive and costly, which limits the rapid adoption of this system for minor crops.

73. (D) Olsen's extractant (0.5 M Sodium Bicarbonate)
Alkaline and calcareous soils contain high levels of calcium carbonate, which precipitates phosphorus as insoluble calcium phosphates. Olsen's extractant, composed of sodium bicarbonate, is buffered at pH eight point five to decrease calcium activity. This allows the extraction of plant-available phosphorus without dissolving highly insoluble mineral phosphate reserves.

74. (A) 0.03 M NH_4F and 0.025 M HCl
This classic soil test extractant is designed for measuring available phosphorus in acidic soils. It consists of a dilute mixture of ammonium fluoride and hydrochloric acid. The fluoride ion is highly effective at complexing aluminum and iron, which releases bound phosphate ions into the solution for accurate chemical quantification.

75. (A) I, II, III, V
Ammonium acetate is the standard reagent for extracting exchangeable potassium. Chelating agents like DTPA extract available trace metals. Hot water extraction is used to measure available soil boron, while the Walkley-Black wet oxidation method estimates organic carbon. Olsen's bicarbonate method is designed for alkaline soils, not acidic soils.

76. (B) To prevent carbonate dissolution and subsequent release of fixed micronutrients.
The chelating extractant DTPA is buffered at pH seven point three to match the typical pH of neutral to slightly alkaline soils. This buffering prevents the dissolution of calcium carbonate minerals, which would otherwise artificially release large amounts of occluded micronutrients, leading to an overestimation of actual plant-available trace metals.

77. (A) Alkaline potassium permanganate method
The alkaline potassium permanganate distillation method is widely used to estimate available nitrogen in soils. This process oxidizes a fraction of the soil organic matter, releasing easily hydrolyzable and mineralizable nitrogen as ammonia. This mineralized fraction correlates well with the nitrogen-supplying capacity of the soil during a crop growing season.

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78. (C) The soil test value below which fertilizer response is highly probable.
The critical limit in soil testing represents the specific nutrient concentration below which a crop is highly likely to respond to fertilizer application. Soils testing below this threshold cannot supply adequate nutrients to sustain optimal growth. Consequently, this value serves as a fundamental guide for making profitable fertilizer recommendations.

79. (D) 0.15% Calcium Chloride (CaCl2)
Calcium chloride solution is the standard extractant for measuring available sulfate-sulfur in soils. The chloride ion displaces weakly adsorbed sulfate from soil complexes, and the calcium ion helps flocculate clay particles, resulting in a clear filtrate. This method provides

a highly reliable estimate of the readily available sulfur pool.

80. (A) P-2, Q-1, R-4, S-3
Walkley-Black wet oxidation determines soil organic carbon levels. Neutral normal ammonium acetate is used to extract exchangeable potassium. The Bray-one method extracts available phosphorus from acidic soils using a fluoride-acid mixture. Chelating DTPA extraction is the standard method for measuring available micronutrients like zinc and iron.

81. (B) DTPA is highly effective in extracting total trace metals from silicate minerals.
The chelating agent DTPA is designed to extract only the labile, plant-available fraction of micronutrients from the soil exchange complex. It is completely incapable of dissolving the highly stable silicate mineral matrix to extract total trace metals. Total elemental analysis requires intense digestion with strong concentrated acids like hydrofluoric acid.

82. (D) Soil fertility is the nutrient-supplying capacity, whereas productivity is the yield performance under management.
Soil fertility is a chemical property representing the inherent capacity of a soil to supply essential nutrients in balanced amounts. Soil productivity is a broader economic concept representing the capacity of a soil to produce crop yields under a specific management system, integrating chemical, physical, and climatic factors.

83. (A) A productive soil must be fertile, but a fertile soil may fail to produce due to environmental constraints.
A productive soil must inherently possess adequate fertility to support crop growth. However, a highly fertile soil may not be productive if physical or environmental factors, such as severe compaction, waterlogging, drought, or extreme temperatures, limit crop development. Fertility is simply one of several components that determine overall soil productivity.

84. (C) The inert primary minerals within the bedrock.
Evaluating soil productivity involves measuring crop yields, economic inputs, and management requirements. In contrast, the inert primary minerals locked deep within the bedrock do not directly influence immediate crop performance. While these minerals contribute to long-term soil formation, they are not used to assess current agricultural productivity.

85. (A) Promoting continuous monoculture cropping systems.
Sustainable soil management aims to enhance productivity by improving physical structure, maintaining organic matter, and optimizing pH. Continuous monoculture cropping degrades soil quality, depletes specific nutrients, and promotes pest accumulation, which severely reduces productivity. Employing diverse crop rotations is essential to sustain long-term soil health and high crop yields.

86. (D) Cation Exchange Capacity (CEC)
Cation exchange capacity is a fundamental chemical property of soil that measures its ability to retain and exchange positively charged nutrients. It is a direct indicator of inherent soil fertility. Parameters like climate, irrigation infrastructure, and economic profitability are external factors used to evaluate overall land productivity.

87. (B) Fertile but unproductive
A soil containing abundant plant-available nutrients is highly fertile. However, if severe waterlogging prevents normal root respiration and stunts crop growth, the soil cannot produce high yields. In this scenario, the environmental constraint renders the soil unproductive, illustrating how physical limitations can suppress the expression of high chemical fertility.

88. (C) By supplying slow-release nutrients and improving physical soil structure.
Soil organic matter is a critical component that drives both soil fertility and productivity. It acts as a major reservoir for essential nutrients, releasing them slowly through mineralization. Physically, it promotes stable soil aggregates, reduces bulk density, and increases water-holding capacity, creating an optimal physical environment for root development and crop growth.

89. (D) Storie Index Rating
This multi-factor soil rating system evaluates land capability by assessing physical properties, profile development, slope, and management constraints. By integrating these diverse physical and chemical characteristics, the

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index provides a numerical rating of potential agricultural productivity, helping land managers and appraisers evaluate overall land quality and capability.

90. (A) Both A and R are true and R is the correct explanation of A.
Soil productivity is dynamic and can be significantly improved through proper management. While inherent soil properties are difficult to alter, management practices like installing drainage systems, applying lime, and irrigating directly overcome environmental and physical limitations. This enables crops to utilize available nutrients, successfully translating soil fertility into high yields.

91. (B) Straight fertilizer
Fertilizers that supply only a single primary macronutrient are classified as straight fertilizers. These materials allow farmers to address specific nutrient deficiencies without applying other elements that may already be abundant in the soil. Classic examples include urea for nitrogen, single superphosphate for phosphorus, and muriate of potash for potassium.

92. (B) Urea
This synthetic compound contains forty-six percent nitrogen and is the most widely used solid nitrogenous fertilizer in the world. It contains no other primary macronutrients, classifying it as a straight fertilizer. It is highly soluble and easily converted into plant-available ammonium, making it highly effective for diverse crops.

93. (A) Complex fertilizers are chemically combined, whereas mixed fertilizers are physical blends.
Complex fertilizers are manufactured through chemical reactions that combine multiple primary nutrients into a single granule, ensuring uniform nutrient distribution. Mixed fertilizers, however, are physical blends of different straight fertilizer materials. This physical mixing can result in nutrient segregation during handling, transport, and field application procedures.

94. (C) 18% N, 46% P2O5
Diammonium phosphate is a highly popular complex fertilizer containing two primary nutrients. Its standard commercial grade contains eighteen percent nitrogen and forty-six percent phosphorus. This high nutrient concentration makes it an exceptionally cost-effective option for supplying phosphorus during planting, while also providing a small starter dose of soluble nitrogen.

95. (A) I, III, IV, V
Urea is an organic compound that serves as a synthetic fertilizer. Muriate of potash is a straight fertilizer supplying only potassium, not a complex one. Liquid fertilizers provide uniform application, and single superphosphate contains essential sulfur and calcium. Bulk blending requires uniform particle sizes to prevent segregation during transport and field application.

96. (C) Segregation during transport and application
When physical fertilizer mixtures contain granules of varying sizes and densities, the individual components tend to separate during transport and handling. This segregation results in uneven nutrient distribution across the field, with some areas receiving excess nitrogen and others receiving insufficient amounts. Using uniform granules is essential to prevent this issue.

97. (B) Urea
Among all solid nitrogenous fertilizers, urea possesses the highest concentration of nitrogen, containing forty-six percent by weight. This high analysis reduces transportation, storage, and application costs per unit of nutrient. Upon application, soil urease enzymes rapidly hydrolyze urea into ammonium, making it readily available for crop uptake.

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98. (D) Ammonium polyphosphate
This clear liquid fertilizer is widely used as a starter fertilizer due to its high solubility and ease of application. It contains nitrogen and phosphorus in a highly plant-available polyphosphate form. The polyphosphate chains undergo rapid hydrolysis in the soil, releasing orthophosphates that plant roots can easily absorb.

99. (A) Mineralization (Ammonification)
Mineralization is the biological process where soil microorganisms decompose organic nitrogen compounds, such as proteins and amino acids, and convert them into inorganic ammonium. This process, also known as ammonification, is a critical step in the nitrogen cycle, transforming unavailable organic nitrogen into a soluble form that plants can readily absorb.

100. (A) P-4, Q-1, R-2, S-3
Diverse heterotrophic microbes drive ammonification, converting organic nitrogen to ammonium. Nitrosomonas bacteria catalyze the first step of nitrification, oxidizing ammonium to nitrite. Nitrobacter bacteria oxidize nitrite to nitrate. Under anaerobic conditions, Pseudomonas and Bacillus bacteria reduce nitrate to nitrogen and nitrous oxide gases, completing the denitrification process.

101. (A) Surface application of urea on alkaline, calcareous soils.
Ammonia volatilization is a chemical loss process that is highly favored by surface applications of urea on alkaline, calcareous soils. The high pH of these soils shifts the chemical equilibrium from soluble ammonium ions to volatile ammonia gas. High temperatures and dry wind further accelerate this gaseous loss into the atmosphere.

102. (D) N_2O and N_2 gases
Denitrification is an anaerobic biological process where specialized bacteria reduce nitrate ions under waterlogged or oxygen-depleted soil conditions. This process converts soluble nitrate into gaseous forms, primarily nitrous oxide and dinitrogen gas, which escape into the atmosphere. This pathway represents a major source of nitrogen loss in agricultural systems.

103. (D) 60:1
Incorporating crop residues with a high carbon-to-nitrogen ratio, such as wheat straw, stimulates rapid microbial growth. Because these residues contain very little nitrogen, soil microorganisms must absorb inorganic nitrogen from the soil solution to build their cellular proteins. This temporary depletion of available soil nitrogen is known as immobilization.

104. (C) Nitrification
Nitrification is a two-step biochemical oxidation process performed by obligate autotrophic bacteria. This pathway requires well-aerated soils with adequate oxygen, as the bacteria must oxidize ammonium to nitrite and subsequently to nitrate. Adequate soil moisture and warm temperatures are also essential to support optimal microbial activity and nitrogen conversion.

105. (A) II, IV, I, III
The biological transformation of nitrogen in soils follows a highly specific chronological sequence. Organic nitrogen is first mineralized into ammonium through the process of ammonification. Autotrophic soil bacteria then oxidize this ammonium into nitrite during the first stage of nitrification, which is subsequently oxidized into highly mobile nitrate.

106. (A) Immobilization results in a permanent loss of nitrogen from the soil ecosystem.
Nitrogen immobilization is a temporary process where inorganic nitrogen is converted into organic forms by soil microorganisms. This organic nitrogen remains within the soil ecosystem and gradually becomes available again through mineralization once the microorganisms die and decompose. Therefore, it does not represent a permanent loss of nitrogen from the soil.

107. (B) Ammonium and Carbon dioxide
Soil urease enzymes rapidly catalyze the chemical hydrolysis of applied urea into ammonium and carbon dioxide. This enzymatic reaction occurs within a few days of application, transforming amide nitrogen into the plant-available ammonium form. This transformation temporarily increases localized soil pH around the fertilizer granule due to the consumption of hydrogen ions.

108. (B) Iron and Aluminum
Under highly acidic soil conditions, soluble orthophosphate ions react rapidly with active iron and aluminum ions. This chemical interaction results in the precipitation of highly insoluble phosphate minerals like variscite and strengite. This strong fixation process severely restricts the availability of phosphorus to plants, locking the nutrient in forms that roots cannot easily absorb.

109. (A) Single super phosphate
Single super phosphate is classified as a water-soluble phosphorus fertilizer because it contains monocalcium phosphate, which dissolves readily in soil water. This rapid dissolution allows plant roots to immediately access orthophosphate ions. In contrast, fertilizers like rock phosphate and dicalcium phosphate require acidic conditions or organic acids to slowly dissolve and release phosphorus.

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110. (A) Both A and R are true and R is the correct explanation of A.
Rock phosphate consists primarily of insoluble apatite minerals that require hydronium ions for dissolution. Strongly acidic soils provide high concentrations of these hydrogen ions, which accelerate the breakdown of the apatite structure, thereby releasing plant-available phosphate. Consequently, rock phosphate application is highly effective in acidic soils but remains largely ineffective in alkaline soil conditions.

111. (D) Calcium phosphate
In calcareous and alkaline soils, high calcium carbonate content and elevated pH levels favor the precipitation of phosphorus. Soluble phosphate ions react with abundant calcium ions to form sequential calcium phosphate compounds, culminating in highly insoluble apatite minerals. This precipitation process significantly reduces phosphorus solubility and availability to growing crops in these specific environments.

112. (C) Citric-soluble P fertilizer
Basic slag is a byproduct of the steel manufacturing industry that contains phosphorus primarily in a citric acid-soluble form. It does not dissolve easily in pure water but dissolves gradually in weak organic acids present in the soil rhizosphere. This characteristic makes it highly suitable for application in acidic soils where it provides sustained phosphorus release.

113. (B) P-solubilization
Phosphorus solubilization is the process through which fixed or insoluble soil phosphorus compounds are converted into plant-available, soluble forms. This phenomenon is largely driven by soil microorganisms and plant roots that exude organic acids and chelating agents. These substances disrupt chemical bonds in insoluble metal-phosphate complexes, releasing orthophosphates into the soil solution.

114. (A) I and II
Water-soluble phosphorus fertilizers perform exceptionally well in alkaline and neutral soils where they can dissolve rapidly, while citric-soluble fertilizers are highly effective in moderately acidic soils due to acid-driven dissolution. Rock phosphate is not useless; it serves as a highly valuable source of phosphorus when applied directly to strongly acidic soils.

115. (A) I and II
Single super phosphate and triple super phosphate are classified as water-soluble phosphorus fertilizers because their phosphorus content exists as monocalcium phosphate, which dissolves instantly in soil water. Dicalcium phosphate is citric-soluble, while rock phosphate and basic slag are water-insoluble, requiring acidic conditions or specific soil biological activity to dissolve and release phosphorus.

116. (C) Dicalcium phosphate dihydrate
Applying water-soluble triple super phosphate to neutral soil initially produces dicalcium phosphate dihydrate as a primary reaction product. This occurs because the highly concentrated, acidic phosphate solution moving outward from the fertilizer granule reacts with calcium ions present in the surrounding soil solution, leading to the rapid precipitation of this moderately soluble phase.

117. (A) Controlled diffusion of urea through the polymer membrane.
Polymer-coated urea controls nitrogen release through the physical process of controlled diffusion. Water vapor first penetrates the semi-permeable polymer membrane, dissolving the solid urea core inside. The resulting concentrated urea solution then slowly diffuses back out into the surrounding soil through microscopic pores in the polymer coating, providing a steady nutrient supply.

118. (D) Microbial oxidation and breakdown of the sulfur coating.
The release of nitrogen from sulfur-coated urea depends primarily on the biological breakdown of its protective coating. Soil microorganisms slowly oxidize the elemental sulfur layer into sulfate. This oxidation process degrades the physical integrity of the coating, creating pathways for water to enter, dissolve the inner urea core, and release the dissolved nitrogen into the soil.

119. (B) Nitrification inhibitor
Neem extract contains natural bioactive compounds, such as epimeliacins, which possess potent bacteriostatic properties. When applied as a coating on urea granules, these compounds temporarily suppress the activity of nitrifying bacteria like Nitrosomonas in the soil. This inhibition delays the biological conversion of

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ammonium to highly mobile nitrate, thereby minimizing potential leaching and gaseous losses.

120. (C) They match nutrient release with crop uptake, reducing losses.
Controlled-release fertilizers are engineered to release nutrients gradually over an extended period. This slow-release profile synchronizes the availability of nutrients with the actual demand and uptake patterns of growing crops. By avoiding sudden spikes in nutrient concentrations, these advanced formulations significantly minimize losses through leaching, denitrification, and ammonia volatilization, thereby improving overall nutrient use efficiency in agriculture.

121. (D) Slow-release nitrogen fertilizer
Urea-formaldehyde is classified as a synthetic slow-release nitrogen fertilizer. It consists of chemically bonded polymers of varying chain lengths that restrict solubility in water. The release of nitrogen from this compound depends on gradual chemical hydrolysis or microbial degradation of the carbon-nitrogen chains, providing a steady supply of available nitrogen over a prolonged period.

122. (A) Soil temperature
Soil temperature is the primary environmental factor controlling the rate of nutrient release from polymer-coated fertilizers. Increased temperature enhances the kinetic energy of water molecules, accelerating their diffusion through the polymer membrane to dissolve the core. Simultaneously, higher temperatures increase the rate at which the dissolved nutrient solution diffuses back out through the coating into surrounding soil.

123. (B) Neem-coated urea reduces ammonia volatilization by acting as a strong urease inhibitor.
Neem-coated urea does not act as a strong urease inhibitor to reduce ammonia volatilization. Instead, its primary mode of action is as a nitrification inhibitor, which works by selectively suppressing the activity of Nitrosomonas bacteria in the soil. This suppression slows the oxidation of ammonium to nitrate, rather than blocking the initial hydrolysis of urea.

124. (B) Meliacin (epimeliacins)
The active chemical principles in neem oil and neem cake responsible for retarding nitrification are triterpenoids known as meliacins, specifically epimeliacins. These bio-active lipid compounds possess specific bacteriostatic properties that selectively inhibit the metabolic processes of Nitrosomonas bacteria, slowing down the biological conversion of stable soil ammonium into highly mobile nitrate.

125. (A) II, IV, I, III
The release of nitrogen from polymer-coated urea follows a precise physical sequence. First, soil water vapor diffuses into the granule through the semi-permeable polymer membrane. Next, the solid urea core dissolves in this moisture. The concentrated liquid urea then diffuses back out through the membrane, where it finally undergoes enzymatic hydrolysis by soil urease.

126. (C) Nitrapyrin (N-Serve)
Nitrapyrin is a widely recognized and utilized commercial nitrification inhibitor in modern agriculture. This organic compound specifically targets and deactivates the ammonia monooxygenase enzyme in Nitrosomonas soil bacteria. By suppressing this specific biochemical pathway, nitrapyrin significantly retards the biological conversion of ammonium to nitrate, reducing risks of environmental pollution and nitrogen loss.

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127. (D) Competitively block the active site of the urease enzyme.
NBPT works as a highly effective urease inhibitor by competitively blocking the active sites of the soil urease enzyme. This chemical block prevents the enzyme from binding to applied urea molecules, thereby slowing down the rate of urea hydrolysis. Consequently, the rapid production of ammonia and localized pH spikes are minimized, reducing volatilization losses.

128. (C) Depressing Nitrosomonas activity to slow nitrification.
Dicyandiamide functions as a targeted nitrification inhibitor by depressing the activity of Nitrosomonas bacteria in the soil. These specific bacteria are responsible for the first, rate-limiting step of nitrification, which converts ammonium into nitrite. Suppressing their metabolic function slows the overall conversion of ammonium to mobile nitrate, keeping nitrogen in a stable form.

129. (B) It acts as a urease inhibitor, reducing volatilization.
Hydroquinone is a phenolic compound that serves as a highly effective urease inhibitor when applied with urea fertilizers. It functions by retarding the enzymatic activity of soil urease, which slows down the conversion of urea into ammonium. This delay helps prevent rapid increases in localized soil pH and subsequent ammonia volatilization losses into the atmosphere.

130. (A) Both A and R are true and R is the correct explanation of A.
Nitrification inhibitors are highly beneficial in coarse-textured sandy soils under intensive rainfall or irrigation because they keep nitrogen in the stable ammonium form. Ammonium carries a positive charge and is held by the soil cation exchange capacity. This prevents its conversion to highly mobile, negatively charged nitrate ions, which are highly susceptible to leaching.

131. (A) Surface urea is highly prone to volatilization, which is mitigated.
Surface-applied urea is directly exposed to wind, heat, and solar radiation, making it exceptionally prone to ammonia volatilization during rapid hydrolysis. Incorporating urea into the soil profile physically traps released ammonia within the soil matrix, reducing gaseous losses. Therefore, urease inhibitors provide the greatest economic and agronomic benefit when applied to surface-broadcast urea.

132. (C) Ammonia monooxygenase in Nitrosomonas
Nitrapyrin achieves its nitrification-inhibiting effect by specifically blocking the activity of the ammonia monooxygenase enzyme within Nitrosomonas bacteria. This key enzyme is responsible for catalyzing the initial conversion of ammonia into hydroxylamine, which is the first step in the oxidation process. Inhibiting this biochemical pathway prevents the subsequent formation of nitrite and nitrate.

133. (A) DCD – Ammonia monooxygenase
Dicyandiamide functions as a nitrification inhibitor by specifically targeting and deactivating the ammonia monooxygenase enzyme. This enzyme is the primary catalyst used by Nitrosomonas bacteria to convert ammonium into nitrite during the first stage of nitrification. Deactivating this enzyme prevents the conversion process, maintaining nitrogen in the stable ammonium form for longer periods.

134. (D) Nitrate leaching and nitrous oxide (N_2O) emissions
Nitrification inhibitors directly mitigate the environmental hazards of nitrate leaching and nitrous oxide emissions. By slowing down the biochemical conversion of ammonium to nitrate, these compounds reduce the concentration of highly mobile nitrate ions in the soil solution. This effectively lowers the amount of nitrogen lost through downward leaching and subsequent anaerobic denitrification processes.

135. (C) II, III, I
Point placement represents the most spatially localized method, concentrating fertilizer into distinct, highly dense spots. Band placement provides intermediate localization by distributing fertilizer along continuous narrow strips adjacent to seed rows. Broadcasting is the most uniformly distributed method, scattering fertilizer evenly across the entire soil surface before or after crop establishment.

136. (C) It reduces soil contact, minimizing phosphorus fixation near roots.
Band placement minimizes the contact surface area between applied phosphorus and soil particles. This physical separation significantly reduces the rate of phosphorus fixation, which is caused by reactions with iron, aluminum, or calcium. Concentrating the nutrient in a concentrated band near developing roots ensures a highly localized, plant-available supply of phosphate during early growth.

137. (D) Correcting acute micronutrient deficiencies when root uptake is limited.
Foliar application is highly effective for rapidly correcting acute micronutrient deficiencies when soil conditions, such as extreme pH or dryness, limit root uptake. Because micronutrients are required in very small quantities, spraying them directly onto plant canopies allows rapid absorption through the leaf stomata and cuticles, bypassing any soil-immobilizing chemical reactions.

138. (A) 100% water solubility
Fertilizers used in fertigation systems must possess 100% water solubility to prevent chemical clogging and physical blockages within narrow

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micro-irrigation lines, filters, and emitters. Any insoluble residues or impurities in the fertilizer can quickly precipitate or settle in the tubing, leading to uneven nutrient distribution and potential failure of the irrigation system.

139. (B) Calcium nitrate and diammonium phosphate
Mixing calcium nitrate and diammonium phosphate in the same fertigation tank is highly discouraged because calcium and phosphate ions readily react to form insoluble calcium phosphate precipitates. These solid precipitates can quickly clog irrigation emitters and filters. To avoid this, calcium and phosphorus fertilizers are typically applied separately or kept in distinct stock tanks.

140. (A) P-2, Q-4, R-1, S-3
Fertigation refers to the application of dissolved fertilizers through irrigation. Foliar application involves spraying dilute nutrient solutions directly onto plant canopies. Pellet application entails deep point placement of nitrogen in lowland rice to avoid the oxidized zone, while band placement positions fertilizer in continuous narrow strips near the active seed rows.

141. (A) Placing urea in the reduced zone to prevent nitrification-denitrification.
Deep placement of urea super granules in flooded rice soils places the nitrogen directly within the anaerobic reduced zone. This hypoxic environment prevents the oxidation of ammonium into mobile nitrate by nitrifying bacteria. Consequently, the nitrogen remains stable as ammonium, preventing the subsequent loss of nitrogen through nitrate leaching and gaseous denitrification in the upper oxidized soil layer.

142. (C) Leaf burn (phytotoxicity) if spray concentration is too high.
A critical risk associated with foliar feeding is leaf burn or phytotoxicity, which occurs if the concentration of the nutrient spray solution exceeds safe thresholds. Excessive chemical concentrations draw water out of leaf cells through osmosis or cause localized toxic accumulations, leading to tissue necrosis, scorched leaf margins, and reduced photosynthetic capacity.

143. (D) Top dressing method
Top dressing is the most practical and effective fertilizer application method for established pastures and mature orchards where deep soil incorporation is not possible. This technique involves distributing fertilizer evenly over the soil surface or established vegetation. The nutrients are then gradually carried downward into the root zone by rainfall, irrigation, or natural moisture.

144. (C) Combining organic, inorganic, and biological sources to sustain fertility and yields.
Integrated Nutrient Management aims to maintain and enhance soil productivity through the systematic, balanced combination of organic manures, inorganic chemical fertilizers, and biofertilizers. This holistic approach focuses on sustaining long-term soil health and crop yields while optimizing nutrient use efficiency, minimizing environmental pollution risks, and reducing heavy reliance on synthetic inputs.

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145. (B) Enhance soil organic matter, nutrient recycling, and physical properties.
Incorporating crop residues in an Integrated Nutrient Management system is primarily performed to enrich soil organic matter and facilitate nutrient recycling. As these plant residues decompose, they release valuable macronutrients and micronutrients back into the soil. Simultaneously, the organic inputs improve soil physical properties, such as aggregation, water retention, aeration, and biological activity.

146. (D) Bradyrhizobium
Bradyrhizobium is a genus of slow-growing, symbiotic soil bacteria specifically recommended as a biofertilizer for soybeans. These specialized bacteria colonize the root system of the soybean plant, forming nodules where they convert atmospheric nitrogen into plant-available ammonia. Incorporating this biological inoculant in crop systems significantly reduces the requirement for synthetic nitrogen fertilizers.

147. (A) Decomposition of organic matter releases organic acids that solubilize it.
The decomposition of organic manures by soil microbes releases carbon dioxide and organic acids, such as citric, malic, and oxalic acids. These organic acids lower the localized soil pH and chelate calcium ions bound to rock phosphate minerals. This biochemical action accelerates the dissolution of insoluble apatite, significantly increasing the release of plant-available orthophosphate.

148. (C) Bacillus megaterium
Bacillus megaterium is a widely utilized phosphate-solubilizing bacterium in integrated nutrient management. This beneficial soil microorganism synthesizes and secretes organic acids, which chelate cations like calcium, iron, or aluminum bound to insoluble phosphates. This biochemical reaction solubilizes fixed soil phosphorus, transforming it into orthophosphates that plant roots can readily absorb and utilize.

149. (A) Biofertilizers directly add physical NPK mass to the soil.
Biofertilizers do not directly add significant physical masses of macronutrients like nitrogen, phosphorus, or potassium to the soil. Instead, they contain living microorganisms that enhance nutrient availability by biologically fixing atmospheric nitrogen, solubilizing insoluble soil phosphorus, or mobilizing potassium. They act as biological catalysts rather than direct chemical nutrient carriers, consequently improving crop nutrient uptake.

150. (A) Both A and R are true and R is the correct explanation of A.
Continuous implementation of Integrated Nutrient Management practices enhances soil buffering capacity and resilience against environmental stresses. The persistent incorporation of organic manures builds up the stable humus pool in the soil, which significantly increases the overall cation exchange capacity. This larger negative charge density allows the soil to resist rapid changes in pH levels.

151. (B) Lowland flooded rice
Azolla is a floating freshwater fern used as an exceptionally effective biofertilizer in lowland flooded rice ecosystems. It maintains a symbiotic relationship with the nitrogen-fixing cyanobacterium Anabaena azollae, which fixes atmospheric nitrogen. Upon incorporation into the waterlogged soil, the Azolla biomass rapidly decomposes, releasing substantial organic nitrogen and improving overall soil health.

152. (C) 15:1 to 20:1
Well-rotted farmyard manure typically possesses a stable Carbon-to-Nitrogen ratio ranging from 15:1 to 20:1. This balanced ratio is optimal for soil application because it matches the requirements of soil decomposer microorganisms. Consequently, it undergoes rapid mineralization to release inorganic plant-available nutrients immediately, avoiding the nitrogen immobilization associated with high carbon-to-nitrogen ratios.

153. (D) $\frac{\text{Yield of fertilized plot} - \text{Yield of control plot}}{\text{Amount of fertilizer applied}}$
Agronomic Efficiency measures the increase in crop economic yield obtained per unit of fertilizer nutrient applied. It is calculated by subtracting the yield of the unfertilized control plot from the yield of the fertilized plot, and then dividing this difference by the total amount of fertilizer nutrient applied to the field.

154. (A) Physiological Efficiency (PE)
Physiological Efficiency evaluates the capability of a crop to transform a unit of absorbed or accumulated nutrient into economic yield. This metric is computed by dividing the difference in economic yield between the fertilized and control plots by the difference in total plant nutrient uptake between those same two treatment groups.

155. (B) II, III, I, IV
Calculating the Apparent Recovery Efficiency of an applied fertilizer begins by determining the total nutrient uptake in the unfertilized control plot. Next, the total nutrient uptake in the fertilized plot is measured. The control uptake is then subtracted from the fertilized uptake. Finally, this difference is divided by the applied nutrient amount and multiplied by one hundred.

156. (B) 50%
Apparent Recovery Efficiency measures the percentage of applied fertilizer nutrient absorbed by the crop. It is calculated by subtracting the nutrient uptake of the control plot from the nutrient uptake of the fertilized plot, and dividing by the fertilizer rate. In this scenario, subtracting thirty from eighty yields fifty, which is fifty percent of the applied rate.

157. (A) High volatilization, denitrification, and leaching losses.
Low apparent recovery efficiency of nitrogen in flooded rice is primarily caused by severe environmental losses. The waterlogged, fluctuating oxidized and reduced zones favor high rates of ammonia volatilization and sequential nitrification-denitrification processes. Additionally, in coarse-textured soils, downward leaching moves highly mobile nitrate ions past

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the shallow, active root systems of young rice plants.

158. (C) $\frac{\Delta Y}{\Delta U}$ (Increase in yield per unit increase in nutrient uptake)
Physiological Efficiency is defined as the economic yield increase achieved per unit increase in plant nutrient uptake. Mathematically, it is represented as delta Y divided by delta U. This ratio isolates the internal efficiency with which the absorbed nutrient is processed, translocated, and utilized by the plant to synthesize harvestable seed, fiber, or tubers.

159. (D) Synchronizing fertilizer application with peak crop demand.
Maximizing the Agronomic Efficiency of an applied fertilizer requires matching the timing of nutrient application with the periods of rapid crop growth and peak nutrient absorption. This tactical synchronization minimizes the duration that nutrients remain exposed to soil-binding or loss pathways, thereby optimizing uptake, enhancing grain production, and reducing fertilizer waste.

160. (A) P-3, Q-1, R-2, S-4
Agronomic Efficiency is measured in kilograms of crop yield increase per kilogram of nutrient applied. Apparent Recovery Efficiency evaluates nutrient recovery expressed as a percentage. Physiological Efficiency is defined as kilograms of yield increase per kilogram of nutrient absorbed. Partial Factor Productivity represents the total kilograms of yield produced per kilogram of nutrient applied.

161. (B) Agronomic efficiency is the product of ARE and PE ($AE = ARE \times PE$).
Agronomic Efficiency is mathematically defined as the direct product of the Apparent Recovery Efficiency and the Physiological Efficiency. This relationship demonstrates that overall yield response per unit of fertilizer applied depends on both the plant's ability to absorb the nutrient from the soil and its internal efficiency in translating that absorbed nutrient into economic yield.

162. (D) The nutrient benefit obtained by the succeeding crop from previous application.
The residual effect represents the carryover benefit where unutilized nutrients applied to a previous crop remain in the soil and become available to support the growth of the succeeding crop. This carryover is particularly significant for immobile nutrients like phosphorus, which adsorb strongly to soil minerals and release slowly into the soil solution over time.

163. (A) Phosphorus
Phosphorus is renowned for its high chemical immobilization and strong residual carryover effect in agricultural soils. Unlike mobile nitrogen, only fifteen to twenty percent of applied phosphorus is typically absorbed by the primary crop. The remaining portion bonds with calcium, iron, or aluminum minerals, remaining in the soil to supply succeeding crops in rotation.

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164. (C) Rice
In a rice-wheat cropping system, applying farmyard manure to the wet rice crop maximizes overall system efficiency. The warm, waterlogged anaerobic soil conditions during the wet season accelerate the decomposition and mineralization of the manure. This rapid decomposition releases plant-available nutrients for the rice crop, leaving significant residual benefits for the succeeding wheat crop.

165. (A) Gradual changes in soil fertility over successive cycles from repeated application.
The cumulative effect of fertilization describes the slow, progressive alterations in soil chemical, physical, and biological properties over multiple cropping seasons. These changes result from the repeated application of fertilizers or manures, which can lead to a gradual buildup of nutrients like phosphorus and potassium, or induce shifts in soil pH and organic carbon.

166. (B) II and III
Leguminous crops biologically fix atmospheric nitrogen, which reduces the nitrogen requirement of the succeeding cereal crop. Phosphorus fertilizers applied to wheat exhibit a substantial residual effect that supports the subsequent rice crop. Additionally, deep-rooted crops in a rotation can absorb leached nutrients from deeper soil layers, thereby optimizing overall cropping system efficiency.

167. (B) Soil carbon and nutrient pool changes occur very slowly over many years.
Direct nutrient responses represent immediate crop reactions to seasonal fertilizer applications, which are easily observed within one year.

In contrast, cumulative effects involve shifts in soil organic carbon, microbial dynamics, physical structure, and stable nutrient pools. These complex biochemical parameters change very slowly and require decades of consistent management to measure accurately in long-term experiments.

168. (C) Reducing subsequent crop fertilizer doses based on heavy potato carryover.
A system-based nutrient management approach considers the residual fertility left by intensive crops in a rotation. Because potato crops receive heavy organic and inorganic fertilizer inputs but possess shallow root systems, they leave substantial unutilized nutrients in the soil. Reducing fertilizer doses for the succeeding wheat crop exploits this residual pool, optimizing system-level economic returns.

169. (D) Intercropping a legume with a cereal completely eliminates the cereal's need for synthetic nitrogen.
Intercropping a leguminous crop with a cereal does not completely eliminate the cereal crop's requirement for synthetic nitrogen. While the legume biologically fixes atmospheric nitrogen, much of this nutrient is consumed internally or remains within its own biomass during the growing season. The cereal crop still requires supplemental nitrogen inputs to achieve its full yield potential.

170. (A) Both A and R are true and R is the correct explanation of A.
Fertilizer recommendations for a crop in rotation differ from monoculture systems because preceding crops alter soil characteristics. Preceding crops modify soil nutrient levels through residual fertilizers, the addition of organic residues with varying carbon-to-nitrogen ratios, and shifts in soil biological activity. This dynamic carryover directly influences the nutrient availability and fertilizer requirements of succeeding crops.

171. (B) Matching nutrient application to field-specific variability and crop demand.
Site-Specific Nutrient Management focuses on dynamically adjusting fertilizer applications to match the specific spatial and temporal variability of fields. Rather than applying broad, regional blanket recommendations, this science-based approach assesses indigenous soil nutrient supply and real-time crop growth requirements. This targeted feeding strategy optimizes nutrient use efficiency while minimizing waste and environmental runoff.

172. (B) Withholding one target nutrient while applying all other nutrients adequately.
The nutrient omission plot technique involves establishing experimental plots where one specific target nutrient is completely withheld while all other essential nutrients are applied in non-limiting quantities. This methodology allows agronomists to isolate and measure the soil's indigenous supply capacity for that omitted nutrient by evaluating the crop yield achieved in its absence.

173. (A) To estimate leaf nitrogen status visually for real-time topdressing.
The Leaf Color Chart serves as a simple, cost-effective tool to visually assess the real-time nitrogen status of cereal leaves in the field. By comparing leaf color against standardized green panels, farmers can determine whether the crop requires immediate nitrogen topdressing. This helps optimize the timing of application, matching it with actual plant demand.

174. (C) Red and Near-Infrared (NIR)
Active optical crop sensors like the GreenSeeker calculate the Normalized Difference Vegetation Index by measuring canopy reflectance in the red and near-infrared spectral regions. Green chlorophyll pigment absorbs red light for photosynthesis, whereas the cellular structure of healthy leaves reflects near-infrared light. The ratio of these two bands reflects crop biomass and nitrogen health.

175. (A) I, II, III, V
Site-Specific Nutrient Management relies on dynamic feeding based on crop needs, utilizing normalized vegetation index sensors to estimate plant biomass and nitrogen status simultaneously. The nutrient omission technique establishes the indigenous soil supply of nutrients. Although the leaf color chart is a simple, inexpensive tool rather than a computerized instrument, SSNM consistently improves nitrogen use efficiency.

176. (C) $\frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$
The Normalized Difference Vegetation Index is computed mathematically by subtracting red light reflectance from near-infrared reflectance,

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and then dividing this value by the sum of near-infrared and red light reflectance. This normalized formulation ranges from negative one to positive one, providing an accurate, standardized indicator of green vegetation density, canopy health, and nitrogen status.

177. (B) The yield response to applied phosphorus, representing field requirement.
The three tons per hectare difference between the fully fertilized plot and the phosphorus-omitted plot represents the specific yield response of the crop to applied phosphorus fertilizer. This difference isolates the physical yield deficit caused by relying solely on the soil's native phosphorus supply, thereby helping agronomists to calculate the exact crop fertilizer requirement.

178. (D) They use an internal light source, permitting use under any ambient light.
Active optical sensors differ from passive sensors by generating their own light source via light-emitting diodes, rather than relying on natural solar radiation. This internal light source allows the sensor to operate consistently under variable ambient conditions, including cloud cover, shade, or complete darkness, without requiring recalibration or experiencing errors due to sunlight fluctuations.

179. (A) It provides a precise, quantitative measure of tissue nitrate.
The Leaf Color Chart is a qualitative, visual diagnostic tool rather than a device that provides precise, quantitative measurements of tissue nitrate concentrations. It operates based on visual correlation between leaf greenness and overall crop nitrogen status. To maintain accuracy, readings must be taken using standardized protocols, such as shielding the leaf from direct glare.

180. (C) B.V. Ramamoorthy
The Targeted Yield Concept for scientific fertilizer recommendation was pioneered in India by B.V. Ramamoorthy. This approach establishes a quantitative relationship between a specific crop yield target, the nutrient requirement to achieve that yield, and the relative nutrient contribution from both the native soil reserves and applied chemical fertilizers in agricultural fields.

181. (A) $F = \frac{NR \times T - CS \times STV}{CF}$
The Soil Test Crop Response approach relies on a fertilizer prescription equation where the nutrient requirement to produce a target yield is balanced against native soil supply. The fertilizer dose equals the total nutrient requirement multiplied by the yield target, minus the soil test value multiplied by its soil contribution coefficient, all divided by the fertilizer contribution coefficient.

182. (A) Both A and R are true and R is the correct explanation of A.
The Soil Test Crop Response model assumes a linear relationship between economic crop yield and total nutrient uptake. This fundamental assumption is based on the biological principle that a specific crop variety requires a definite, predictable quantity of nutrient uptake to synthesize one unit of economic yield under given agro-climatic conditions.

183. (B) Nutrients from both native soil supply and applied fertilizer.
Roger H. Bray modified the original Mitscherlich equation to develop the nutrient mobility concept. This modification allowed the mathematical model to simultaneously account for the different availability and uptake efficiencies of nutrients coming from both the native soil reserve, which represents a less mobile pool, and newly applied chemical fertilizers, which are highly mobile.

184. (C) Nutrient requirement, soil efficiency, and fertilizer efficiency.
Developing site-specific Soil Test Crop Response calibration equations requires calculating three primary parameters from field experiments. These are the nutrient requirement of the crop to produce one unit of economic yield, the efficiency of the soil in supplying available nutrients, and the relative efficiency of applied chemical fertilizers in delivering nutrients to the plant.

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185. (C) I and III
The Targeted Yield Concept accounts for nutrients supplied by both soil reserves and applied fertilizers, while modern Soil Test Crop Response equations can be calibrated to include nutrient contributions from organic manures. The Mitscherlich-Bray equation is fully capable of predicting crop yield responses to varying fertilizer rates, making the second statement incorrect.

186. (A) P-1, Q-2, R-3, S-4
The Soil Test Crop Response targeted yield model was developed by B.V. Ramamoorthy. The Law of the Minimum, stating that crop growth is limited by the scarcest nutrient, was formulated by Justus von Liebig. E. Mitscherlich proposed the Law of Diminishing Returns, and R.H. Bray developed the Nutrient Mobility Concept in agriculture.

187. (B) The calculated dose becomes excessively high, causing economic and eco damage.
Setting an unrealistically high yield target in Soil Test Crop Response equations results in the mathematical calculation of excessively high fertilizer doses. Because the model attempts to meet nutrient demands beyond the physiological and agro-climatic potential of the crop, the excess fertilizer is not absorbed, causing financial waste and severe environmental damage.

188. (B) Nitrate
Methemoglobinemia is a serious human health condition caused by drinking water contaminated with high levels of nitrate. In the digestive system, nitrate is reduced to nitrite, which binds strongly to hemoglobin, forming methemoglobin. This compound cannot transport oxygen, leading to clinical oxygen deprivation, characterized by a bluish skin color in infants.

189. (A) Eutrophication
Eutrophication is the ecological process that occurs when freshwater bodies receive excess agricultural phosphorus through surface runoff. Phosphorus is often the limiting nutrient in freshwater ecosystems, so its sudden influx triggers explosive growth of algae and aquatic weeds. This massive bloom blocks sunlight and depletes dissolved oxygen as the vegetation decomposes, harming aquatic life.

190. (C) Nitrous oxide (N_2O)
Nitrous oxide is a potent greenhouse gas with a global warming potential nearly three hundred times greater than carbon dioxide. It is primarily generated in agricultural soils as a chemical byproduct during the microbiological processes of nitrification under aerobic conditions and denitrification under anaerobic, waterlogged soil conditions, especially after heavy nitrogen fertilization.

191. (D) Sandy soils under heavy rainfall or excessive irrigation.
Nitrate leaching is most severe in coarse-textured sandy soils under climates with heavy rainfall or excessive irrigation. Sandy soils possess low cation and anion exchange capacities along with large macropores, allowing water to drain rapidly. Because negatively charged nitrate ions do not adsorb to clay surfaces, they leach downward through the root zone into groundwater.

192. (C) Oxygen depletion caused by decomposition of massive algal blooms.
Eutrophication results in widespread fish mortality primarily due to critical oxygen depletion. When the massive algal blooms triggered by excess nutrients die, heterotrophic bacteria decompose the dead organic matter. This biological decomposition consumes vast amounts of dissolved oxygen, creating hypoxic or anoxic conditions that literally suffocate fish and other oxygen-dependent aquatic organisms.

193. (B) Using nitrification inhibitors and optimizing application rates.
Mitigating agricultural nitrous oxide emissions is achieved most effectively by utilizing nitrification inhibitors and optimizing fertilizer application rates. Nitrification inhibitors temporarily block the conversion of stable ammonium into nitrate, minimizing the pool of nitrate available for anaerobic denitrification. This action, combined with precise rate optimization, reduces the gaseous byproducts of both biochemical pathways.

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194. (D) Excess potassium fertilizer is the primary cause of coastal dead zones.
Excess potassium fertilizer is not the primary driver of coastal dead zones. These hypoxic marine zones are caused by nitrogen and phosphorus runoff, which trigger massive algal blooms that deplete dissolved oxygen upon decomposition. Potassium is not a limiting nutrient in marine aquatic environments, making its environmental impact on dead zones highly negligible.

195. (A) I and II
Nitrous oxide is indeed a highly potent greenhouse gas with a global warming potential nearly three hundred times that of carbon dioxide. Furthermore, because nitrate is a negatively charged anion, it is repelled by negatively charged soil clay particles, leaving it highly mobile and

prone to leaching. Eutrophication occurs in both freshwater and marine ecosystems.

196. (C) Cadmium (Cd)
Continuous application of phosphatic fertilizers, such as single super phosphate and rock phosphate, is a primary source of cadmium contamination in agricultural soils. Cadmium exists naturally as an impurity in geological rock phosphate deposits. During chemical processing, this toxic heavy metal is carried over into the final fertilizer products, where it slowly accumulates in soil.

197. (A) Extensive irrigation with untreated municipal and industrial wastewater.
Peri-urban agricultural soils face high risks of heavy metal contamination due to the widespread practice of irrigating crops with untreated municipal and industrial wastewater. This wastewater often contains high concentrations of toxic elements like lead, cadmium, chromium, and nickel. Over years of irrigation, these heavy metals accumulate in the topsoil, threatening food safety.

198. (D) Cadmium (Cd)
Itai-itai disease is a chronic condition caused by mass cadmium poisoning, documented historically in Japan. The disease was triggered by the consumption of rice grown in soils irrigated with cadmium-contaminated mining wastewater. Cadmium accumulated in the rice grains and, when ingested, damaged the kidneys and disrupted calcium metabolism, leading to excruciating bone softening and fractures.

199. (B) The Bengal Delta plain of South Asia
The Bengal Delta plain of South Asia, spanning Bangladesh and West Bengal, experiences a severe biogeochemical disaster due to widespread arsenic contamination in groundwater. Utilizing this arsenic-laden groundwater for irrigating paddy fields results in the toxic accumulation of arsenic in the soil and its subsequent uptake by rice crops, posing severe health risks.

200. (A) Both A and R are true and R is the correct explanation of A.
Hexavalent chromium is significantly more toxic and mobile in soils than trivalent chromium. Trivalent chromium forms stable, insoluble oxide or hydroxide precipitates under typical soil pH ranges, reducing its bioavailability. In contrast, hexavalent chromium exists as highly soluble anionic species, such as chromate, which are poorly adsorbed by negatively charged soil components.

201. (A) P-4, Q-2, R-3, S-1
Cadmium enters agricultural soils primarily as an impurity in rock phosphate fertilizers. Lead contamination is often linked to historical deposits from leaded gasoline exhaust settling on fields. Arsenic is introduced mainly through contaminated groundwater used for irrigation, while chromium is a primary pollutant in tannery effluent and untreated industrial wastewater.

202. (A) Complexation with organic matter and precipitation as insoluble salts.
Lead is highly immobile in agricultural soils because it binds strongly to soil components. It undergoes intense complexation with organic matter fractions, particularly humic substances, and forms insoluble mineral precipitates with phosphates, carbonates, and hydroxides. This strong binding behavior keeps lead in the topsoil and limits its uptake by plant roots.

203. (B) They promote chlorophyll synthesis, leading to hyper-photosynthesis.
Heavy metals do not promote chlorophyll synthesis or enhance photosynthesis. Instead, they disrupt chlorophyll production by interfering with essential enzymes or substituting for the central magnesium ion in the chlorophyll molecule. This chemical displacement leads to chlorosis, impaired light absorption, damaged photosynthetic structures, and a severe decline in crop growth.

204. (B) Phytoextraction
Phytoextraction is the specific phytoremediation technique where hyperaccumulator plants absorb heavy metal contaminants from the soil through their roots. These plants then translocate and concentrate the metals into their harvestable above-ground tissues, such as stems and leaves. Once the plants mature, they are harvested and safely incinerated, permanently removing the contaminants.

205. (A) Phytostabilization immobilizes contaminants, while phytoextraction removes them via uptake.
Phytostabilization focuses on immobilizing heavy metal contaminants within the soil matrix using plant roots to reduce their bioavailability and

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prevent migration. In contrast, phytoextraction actively removes the contaminants from the soil by taking them up through the root system and translocating them into harvestable shoots for physical removal from the site.

206. (C) Raising soil pH to precipitate metals as insoluble compounds, reducing bioavailability.
Applying agricultural lime to heavy-metal contaminated soils raises the soil pH. This decrease in acidity promotes the precipitation of dissolved heavy metal cations, transforming them into insoluble hydroxides, carbonates, or phosphates. This precipitation significantly reduces the concentration of bioavailable metals in the soil solution, minimizing their uptake by plant roots.

207. (D) Pteris vittata (Chinese brake fern)
Pteris vittata is a highly specialized hyperaccumulator fern renowned for its extraordinary capacity to absorb and accumulate arsenic. This plant extracts arsenic from contaminated soils and water, rapidly translocating it from roots to fronds where it stores it in non-toxic forms. This exceptional physiological trait makes it a primary species used for arsenic phytoextraction.

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208. (C) I and III
Applying biochar binds heavy metals through adsorption, while adding organic matter decreases the mobility of metals like lead and copper by forming stable insoluble complexes. Phytoextraction, however, is restricted to the shallow root zone and is not effective for rapidly cleaning up deeply contaminated groundwater aquifers, making the second statement incorrect.

209. (B) Altering metal oxidation states to reduce toxicity and mobility.
Microorganisms cannot physically destroy heavy metals, so bioremediation relies on altering their chemical forms. Soil microbes secrete enzymes or metabolic products that change the oxidation states of heavy metals. This oxidation or reduction process significantly reduces the toxicity, solubility, and mobility of the target metals, precipitating them into stable, less bioavailable mineral forms.

210. (D) Phosphatic amendments
Phosphatic amendments, such as rock phosphate or triple super phosphate, are highly effective for in situ remediation of lead-contaminated soils. The added phosphate ions react rapidly with soluble lead cations to precipitate pyromorphite, an extremely stable and insoluble lead phosphate mineral. This chemical transformation permanently reduces lead bioavailability and leaching risk.

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CHAPTER 04
Dryland Agronomy

2024

1. Which of the following precipitation thresholds accurately distinguishes dry farming from dryland farming in the traditional classification system?
(A) Cultivation of crops in areas receiving less than 500 mm annually
(B) Cultivation of crops in areas receiving less than 750 mm annually
(C) Cultivation of crops in areas receiving between 750 mm and 1150 mm annually
(D) Cultivation of crops in areas receiving more than 1150 mm annually

2018

2. In which year were the first Dry Farming Research Stations systematically established in India to address moisture stress?
(A) 1929
(B) 1933
(C) 1959
(D) 1970

2023

3. Which biophysical constraint predominantly limits initial crop establishment in the alfisols of dryland ecosystems?
(A) Severe surface crusting due to poor structural stability
(B) Extremely high inherent organic carbon content
(C) Excessive capillary rise of saline groundwater
(D) Sub-surface hardpan formation from repeated mechanical puddling

2006

4. In Thornthwaite's climatic classification system, the moisture index is primarily derived from which of the following variables?
(A) The ratio of annual precipitation to mean temperature
(B) The number of humid months exceeding 50 mm rainfall
(C) The balance between precipitation and potential evapotranspiration
(D) The frequency of consecutive dry spells during the monsoon

2009

5. What is the correct hierarchical order of watershed categories from smallest to largest based on standard area classifications?
I. Sub-watershed
II. Micro-watershed
III. Macro-watershed
IV. Milli-watershed
V. Mini-watershed
Choose the correct answer from the options given below:
(A) V, II, IV, I, III
(B) V, II, I, IV, III
(C) II, V, IV, I, III
(D) II, IV, V, I, III

2009

6. When utilizing Markov chain probability models in dryland agriculture, what does the conditional probability specifically measure?
(A) The likelihood of receiving rainfall on a given day regardless of previous days
(B) The total percentage of rainfall deviation from the annual mean
(C) The statistical median of rainfall distribution across a decadal dataset
(D) The probability of a wet week occurring immediately after a dry week

2007

7. The Length of Growing Period (LGP) is determined as the continuous period during the year when precipitation exceeds which specific threshold?
(A) 25 percent of potential evapotranspiration
(B) 50 percent of potential evapotranspiration
(C) 75 percent of potential evapotranspiration
(D) 100 percent of potential evapotranspiration

2002

8. Which type of drought is strictly defined as a period of abnormal dry weather sufficiently prolonged for the lack of water to cause significant hydrological imbalance in streamflows and reservoirs?
(A) Meteorological drought
(B) Agricultural drought

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(C) Hydrological drought
(D) Socio-economic drought

2010
9. During severe drought stress, plants often exhibit enhanced accumulation of specific biochemical compounds. Which amino acid is most universally recognized for its role in osmotic adjustment under moisture stress?
(A) Methionine
(B) Glutamate
(C) Tryptophan
(D) Proline

2002
10. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Ephemeral desert plants primarily utilize drought escape mechanisms rather than drought tolerance.
Reason (R): Ephemerals complete their entire life cycle rapidly during brief periods of moisture availability, thereby avoiding the stress period entirely.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2018
11. Which of the following chemicals acts as a stomatal closing type of antitranspirant?
(A) Finely divided Kaolin clay powder
(B) Phenyl Mercuric Acetate (PMA)
(C) Long-chain fatty Hexadecanol alcohol
(D) Silicone-based Mobileaf emulsion

2007
12. In the context of mid-season agronomic corrections for prolonged dry spells, what is the primary physiological purpose of a 2 percent urea foliar spray?
(A) To induce rapid defoliation and reduce overall transpirational surface area
(B) To revive physiological activity and enhance photosynthetic efficiency upon recovery
(C) To permanently close stomata for the remainder of the cropping season
(D) To increase the albedo of the crop canopy and lower leaf temperature

2012
13. Which of the following best explains why ratooning is recommended as a mid-season correction for certain crops during severe moisture stress?
(A) It removes transpiring biomass to allow basal regrowth upon subsequent rainfall
(B) It completely eliminates resource competition from late-emerging weed species
(C) It induces highly accelerated physiological flowering and increases grain test weight
(D) It alters the active root distribution from shallow fibrous to a deep taproot system

2024
14. In dryland cropping systems, what is the primary agronomic rationale for selecting an intercropping system over a sole crop?
(A) To completely eliminate the need for synthetic nitrogenous fertilizer applications
(B) To maximize the potential yield of a single high-value commercial cash crop
(C) To provide biological insurance against total crop failure under erratic rainfall
(D) To facilitate higher mechanical efficiency during large-scale harvesting operations

2009
15. What is the correct sequence of soil moisture conservation techniques when arranged by their typical application scope from field-level micro-catchment to larger drainage-line treatments?
(A) Compartmental bunding, Check dams, Broad Bed and Furrow (BBF), Percolation tanks
(B) Percolation tanks, Check dams, Compartmental bunding, Broad Bed and Furrow (BBF)
(C) Compartmental bunding, Broad Bed and Furrow (BBF), Percolation tanks, Check dams
(D) Broad Bed and Furrow (BBF), Compartmental bunding, Check dams, Percolation tanks

2013
16. What is the fundamental physical mechanism by which a dust mulch conserves sub-surface soil moisture?
(A) It acts as a highly reflective surface that significantly reduces incoming solar radiation
(B) It chemically binds with surface soil water molecules to prevent evaporation losses
(C) It breaks capillary pore channels, interrupting upward movement of soil water

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evapotranspiration.
III. LGP is identical across all agro-ecological zones within the same latitude.
IV. The humid period within the LGP occurs when precipitation exceeds full potential evapotranspiration.
Which of the statements given above are INCORRECT?
(A) I, II and IV
(B) I and III
(C) II and IV
(D) I, III and IV

2008
34. Which socio-economic constraint most severely restricts the adoption of mechanized precision agronomy in traditional dryland agriculture?
(A) Widespread availability of highly subsidized chemical fertilizers
(B) Government mandates strictly prohibiting tractor usage in drylands
(C) Excessive market demand for organically certified local landraces
(D) Fragmentation of landholdings and lack of capital for machinery

2005
35. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Dry seeding is often practiced in dryland areas prior to the onset of the monsoon.
Reason (R): Dry seeding allows crops to fully utilize the early season rainfall, ensuring rapid germination as soon as adequate moisture is received.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2003
36. Which of the following constitutes a primary physiological symptom of the "drought syndrome" in agricultural crops?
(A) Uncontrolled elongation of internodes
(B) Significant thickening of the primary root cortex
(C) Premature leaf senescence and floral abortion
(D) Excessive tillering leading to a dense canopy

2017
37. Among the types of mulches utilized to reduce evapotranspiration, which material distinctly modifies the micro-climate by increasing soil temperature during the day while retaining moisture?
(A) Clear polyethylene mulch
(B) Organic crop stubble residues
(C) Reflective white kaolin powder
(D) Dry loose soil or dust mulch

2003
38. In the event of a prolonged dry spell occurring during the vegetative stage, which mid-season correction is structurally designed to optimize the limited available soil moisture per plant?
(A) Top-dressing with heavy doses of diammonium phosphate
(B) Broadcasting weed seeds to provide a living mulch
(C) Applying defoliants to instantly kill the crop
(D) Deep intra-row crop thinning

2018
39. Which institutional entity was specifically established in 1972 at Patancheru to conduct extensive research on semi-arid tropic agriculture?
(A) Central Arid Zone Research Institute located in Jodhpur, Rajasthan
(B) International Crops Research Institute for the Semi-Arid Tropics
(C) Central Research Institute for Dryland Agriculture located in Hyderabad
(D) Indian Institute of Soil and Water Conservation located in Dehradun

2005
40. What is the correct sequence of water harvesting and utilization efficiency, from highest priority source conservation to final application?
I. Supplemental irrigation
II. In-situ moisture conservation
III. Catchment runoff generation
IV. Farm pond storage
Choose the correct answer from the options given below:
(A) III, II, IV, I
(B) III, IV, II, I
(C) II, III, IV, I
(D) II, IV, III, I

2022
41. The Moisture Availability Index (MAI) proposed by Hargreaves is calculated using which two specific parameters?
(A) Mean annual rainfall and mean annual

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moisture falls below the level required by crops.
II. Meteorological drought is characterized strictly by declining groundwater tables.
III. The Moisture Availability Index is used to assess agricultural drought risk.
Which of the statements given above are correct?
(A) I and II
(B) II and III
(C) I only
(D) I and III

2004
26. In contingency crop planning for a delayed onset of monsoon, which adaptive strategy is most scientifically appropriate?
(A) Substituting long-duration crops with short-duration, drought-escaping crops
(B) Increasing the overall seeding rate of traditional long-duration crop varieties
(C) Applying high doses of basal nitrogenous fertilizer to force rapid vegetative growth
(D) Delaying preparatory land tillage operations until the monsoon season fully establishes

2004
27. Cycocel (CCC) is frequently discussed in drought management. What is its primary physiological classification and function?
(A) It is a film-forming antitranspirant that creates a physical barrier to water vapor on the leaf surface
(B) It is a growth retardant that restricts shoot growth and increases root-to-shoot ratio
(C) It is an active osmoticant applied directly to root zones to increase overall water uptake velocity
(D) It is a highly reflective kaolin-based compound that significantly increases leaf surface albedo

2017
28. Which definition accurately describes the concept of conditional probability using the Markov chain model in rainfall analysis?
(A) The absolute sum of cumulative rainfall received over a specific, designated decadal period
(B) The probability of a weather state occurring given the state of the preceding period
(C) The probability of an entire agricultural season being classified as a meteorological drought
(D) The statistical variance of potential evapotranspiration rates over a specific geographical grid

2024
29. Reactive Oxygen Species (ROS) generation is a critical biochemical effect of drought stress. Which of the following accurately describes a plant's primary enzymatic defense mechanism against ROS?
(A) Upregulating superoxide dismutase and catalase enzymes
(B) Accelerating the degradation pathways of active chlorophyll pigments
(C) Inducing the complete biochemical cessation of the Calvin cycle
(D) Significantly enhancing the exudation of organic acids from roots

2005
30. Which of the following pairs concerning antitranspirants is correctly matched?
(A) Kaolin – Stomatal closing type
(B) PMA (Phenyl Mercuric Acetate) – Reflectant type
(C) Hexadecanol – Film-forming type
(D) Atrazine – Growth retardant

2016
31. Under dryland conditions, which alternate land use system deliberately integrates woody perennials with arable crops on the same land management unit?
(A) Silvi-pasture
(B) Horti-pastoral system
(C) Intensive sole-cropping
(D) Agri-silviculture

2008
32. What is the fundamental purpose of constructing Broad Bed and Furrows (BBF) in deep black soils (Vertisols)?
(A) To completely prevent surface water runoff, forcing one hundred percent infiltration
(B) To lower the soil pH by promoting the rapid accumulation of organic matter in furrows
(C) To safely dispose of excess runoff while conserving in-situ soil moisture
(D) To create a saturated micro-environment designed exclusively for aquatic crop species

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2001
33. Consider the following statements regarding the Length of Growing Period (LGP):
I. LGP calculations ignore the moisture stored in the soil profile.
II. LGP begins when precipitation equals or exceeds half of the potential

(D) III only

2007

65. What distinguishes a percolation tank from a standard farm pond in a watershed management framework?
(A) Percolation tanks are fully lined with high-density polyethylene to completely prevent water loss
(B) Percolation tanks impound runoff specifically for localized groundwater recharge
(C) Percolation tanks are constructed solely for intensive commercial aquaculture production in villages
(D) Percolation tanks are positioned exclusively at the highest topographic ridge line of the watershed

2013

66. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Stomatal closing antitranspirants simultaneously decrease both transpiration and photosynthesis.
Reason (R): The physical closure of stomata restricts the outward diffusion of water vapor as well as the inward diffusion of carbon dioxide.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2001

67. Which specific aridity classification system utilizes the ratio of the number of humid months (where precipitation exceeds PET) to delineate dryland tracts into arid, semi-arid, and sub-humid zones?
(A) Troll's System
(B) Thornthwaite's System
(C) Koppen's System
(D) Hargreaves' System

2002

68. In evaluating dry spell frequency during the monsoon, what statistical advantage does the Markov chain model provide over simple arithmetic averaging?
(A) It predicts the exact volume of cumulative rainfall in millimeters for the upcoming cropping week
(B) It entirely and systematically eliminates the uncertainty associated with regional climate change
(C) It calculates the sequential dependency of wet and dry periods using probabilities
(D) It determines the absolute maximum atmospheric temperature during the peak of the dry spell

2014

69. Which of the following is a primary objective of crop residue management within dryland conservation agriculture?
(A) Moderating soil temperature and enhancing moisture retention
(B) Complete removal of surface biomass for intensive industrial fuel utilization
(C) Increasing the surface albedo of the soil to cool the regional macro-climate
(D) Rapidly depleting soil nitrogen levels to prevent excessive vegetative lodging

2018

70. When considering the biophysical constraints of dryland soils, what does the term "soil crusting" specifically refer to?
(A) The natural accumulation of thick organic plant litter on the undisturbed forest floor
(B) The deliberate compaction of surface soil by heavy machinery to increase capillary rise
(C) The chemical precipitation of calcium carbonate in the deep sub-surface soil horizons
(D) Formation of a dense surface layer upon drying that inhibits seedling emergence

2016

71. In contingency planning for a prolonged dry spell during the mid-season, which intervention is primarily intended to physically salvage the remaining soil moisture for a reduced plant population?
(A) Immediate foliar application of highly powerful selective chemical herbicides
(B) Strategic crop thinning by removing alternate rows or weaker plants
(C) Heavy manual application of basal farmyard manure over the dry crop canopy
(D) Inducing localized artificial rainfall through large-scale chemical cloud seeding

2025

72. Consider the following statements concerning antitranspirants and growth retardants:

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temperature across the target zone
(B) Daily pan evaporation and saturated hydraulic conductivity of local soils
(C) Total monsoon precipitation and soil organic carbon percentage of the area
(D) Assured rainfall at 75% probability and reference evapotranspiration

2003

42. In conservation cropping practices, reduced tillage primarily aims to achieve which specific agronomic outcome?
(A) Minimizing soil disturbance to retain residues and preserve structure
(B) Complete mechanical inversion of the soil profile to bury all weed seeds deep
(C) Disruption of the sub-surface soil hardpan using deep mechanical subsoilers annually
(D) Acceleration of surface organic matter decomposition to quickly release mineral nitrogen

2007

43. Which plant adaptation mechanism is characterized by the physical folding or rolling of leaves to decrease the transpirational surface area during intense mid-day heat?
(A) Drought escape
(B) Drought avoidance
(C) Drought tolerance
(D) Osmotic adjustment

2015

44. Consider the following statements concerning fertilizer management in dryland conditions:
I. Aqua-fertigation involves injecting nutrients directly into the root zone along with minimal water.
II. Basal fertilizers should be broadcasted on the soil surface to prevent leaching.
III. Split application of nitrogen is highly effective if timed with active rainfall events.
IV. Foliar application of nutrients is completely ineffective during prolonged dry spells.
Which of the statements given above are correct?
(A) I and II
(B) I and III
(C) I, III and IV
(D) II, III and IV

2001

45. Match List I with List II and select the correct answer.
List I: Integrated Watershed Management Component
P. Contour farming
Q. Percolation tanks
R. Silvi-pasture
S. Dry seeding
List II: Primary Functional Outcome
1. Fodder production and land stabilization
2. Interception of runoff across the slope
3. Timely establishment utilizing early rains
4. Deep groundwater recharge
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

2001

46. What is the standard definition of "rainfed farming" in relation to the nature of crop production?
(A) Cultivation utilizing supplemental groundwater pumping during dry seasons
(B) Cultivation where 50 percent of the water requirement is met by canal irrigation
(C) Cultivation dependent on rainfall without supplemental irrigation
(D) Cultivation exclusively in arid zones receiving less than 200 mm of rain

2015

47. Which mathematical relationship correctly represents the calculation for initial probability in rainfall analysis using weekly historical data?
(A) Number of consecutive dry weeks multiplied by annual precipitation
(B) Standard deviation of rainfall divided by the mean rainfall
(C) The natural logarithm of total cumulative monsoon seasonal precipitation
(D) Number of wet weeks divided by total weeks in the dataset

2004

48. During severe agricultural drought, which primary crop physiological process is impaired first, leading to a cascade of developmental failures?
(A) Phloem loading and translocation of complex structural proteins
(B) Mitochondrial oxidative phosphorylation in non-photosynthetic tissue
(C) Cell expansion and division due to turgor loss
(D) Synthesis of protective secondary metabolites like condensed tannins

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completely flat, un-sloped bottom surface
(B) Planting deep-rooted trees directly on the interior sloping walls of the farm pond
(C) Constructing the farm pond at the highest possible topographic elevation in the watershed
(D) Applying artificial lining materials to prevent seepage losses

2004

80. Consider the following statements concerning mid-season corrections in dryland agriculture:
I. Ratooning is recommended for crops like sorghum if the main shoot is severely stunted by drought but late rains occur.
II. Urea foliar spray is used to rapidly revive crop foliage after a dry spell breaks.
III. Crop thinning increases inter-plant competition for available moisture.
IV. Life-saving irrigation should ideally be applied during the lag vegetative phase rather than critical reproductive stages.
V. Weeding must be delayed during a dry spell to allow weeds to shade the crop.
Which of the statements given above are correct?
(A) I, II and IV
(B) II, III and V
(C) I and II
(D) I, IV and V

2017

81. In defining dryland farming zones based on rainfall limits (750 mm to 1150 mm), which of the following is typically a defining characteristic of crop production in these regions?
(A) The predominant agricultural reliance on high-water-demanding crops like flooded lowland rice
(B) Emphasizing moisture conservation and drought-tolerant cropping systems
(C) Frequent, near-certain crop failures due to an absolute lack of seasonal precipitation events
(D) Total agricultural reliance on deep tubewell extraction systems throughout the cropping year

2009

82. Which of the following plant species is a classic example of utilizing drought escape by rapidly completing its life cycle before soil moisture is fully depleted?
(A) Deep-rooted Acacia tortilis desert trees
(B) Slow-growing, perennial xerophytic cacti
(C) Deep-water floating rice varieties of wetlands
(D) Short-duration pearl millet varieties

2018

83. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Intercropping is a highly recommended practice in rainfed agriculture.
Reason (R): Intercropping exclusively utilizes species with identical root architectures and maturity durations to maximize resource competition.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2016

84. Which method of fertilizer application ensures that basal nutrients remain available to crop roots even as the topsoil rapidly dries out?
(A) Surface broadcasting of highly soluble granular fertilizers
(B) Aerial top-dressing of agricultural fields during dry periods
(C) Basal deep placement using seed drills
(D) Dissolving active chemical nutrients directly in runoff water

2009

85. What is the fundamental concept underlying the Length of Growing Period (LGP)?
(A) Duration when soil moisture and temperature are adequate for active crop growth
(B) The total number of actual calendar days between the date of sowing and physical harvesting
(C) The period during which ambient air temperature remains strictly above zero degrees Celsius
(D) The specific number of hours of daylight required to triggers photoperiodic floral initiation

2011

86. Which integrated watershed management component focuses on stabilizing highly degraded, uncultivable upper slopes while providing economic returns?
(A) Intensive double-cropping of cereals
(B) Deep plowing and clean cultivation

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2006

57. Which concept correctly explains the operation of a "life-saving irrigation" in rainfed agriculture?
(A) Continuous application of irrigation water throughout the crop cycle to maximize yields
(B) Flooding the field completely before sowing to ensure a fully saturated soil profile
(C) Applying excessive amounts of irrigation water to leach accumulated surface salts deep
(D) Targeted water application during critical stages to prevent crop failure

2021

58. The Central Arid Zone Research Institute (CAZRI), pivotal in desertification and dryland studies, is located in which Indian city?
(A) Jodhpur
(B) Hyderabad
(C) New Delhi
(D) Dehradun

2003

59. When formulating a contingency crop plan for a region facing a highly erratic rainfall distribution, which specific crop characteristic is prioritized above all others?
(A) Exceptionally high yield potential under optimum conditions
(B) Phenological plasticity and short duration
(C) Maximum possible leaf area index
(D) Requirement for intensive chemical fertilization

2008

60. Match List I with List II and select the correct answer.

List I: Drought Adaptation Mechanism
P. Drought Escape
Q. Drought Avoidance
R. Osmotic Adjustment
S. Reflectance

List II: Plant Physiological Example
1. Ephemeral life cycle completion
2. Accumulation of intracellular proline
3. Glaucous wax coating on leaves
4. Extensive taproot development

(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-1, Q-2, R-4, S-3
(D) P-2, Q-4, R-1, S-3

2021

61. Which specific crop physiological stage is generally universally recognized as the most sensitive to moisture stress, resulting in the most severe yield penalties if drought occurs?
(A) Early vegetative growth
(B) Active tillering or branching
(C) Anthesis and active grain filling
(D) Physiological maturity and senescence

2009

62. Which of the following best describes the "dust mulch" technique historically utilized in dry farming?
(A) Applying a thick layer of imported organic compost over the entire cultivated field surface
(B) Spraying fine clay particles suspended in water onto the plant canopy to reduce transpiration
(C) Shallow inter-cultivation creating a loose topsoil layer to break capillary continuity
(D) Allowing wind-blown sand particles to naturally accumulate over active agricultural crop rows

2019

63. Under erratic rainfall conditions, which spatial arrangement in intercropping systems typically optimizes the complementary use of varying soil moisture profiles by combining deep-rooted and shallow-rooted crops?
(A) Random broadcasting of mixed seeds of both crops across the entire field
(B) Solid planting of the primary crop with specialized border rows of the intercrop
(C) Planting both companion crops in identical, strictly superimposed seeding holes
(D) Defined row-proportions utilizing additive or replacement series

2013

64. Consider the following statements regarding fertilizer application in drylands:
I. Deep placement of basal fertilizer enhances root proliferation into deeper, moister soil layers.
II. Top-dressing of solid nitrogenous fertilizers during severe dry spells is highly recommended.
III. Split application helps in adjusting the fertilizer dose based on subsequent rainfall receipts.

Which of the statements given above are INCORRECT?
(A) I and II
(B) I and III
(C) II only

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(D) It significantly increases the specific heat capacity of the surface soil layer

2014

17. Check dams are crucial rainwater harvesting structures in integrated watershed management. What is their primary functional role?
(A) To permanently store large volumes of water for extensive canal irrigation networks
(B) To reduce runoff velocity, trap sediment, and recharge local groundwater
(C) To generate localized micro-hydroelectric power for adjacent farming communities
(D) To channelize agricultural surface runoff directly into deep saline aquifer zones

2016

18. Among the following lining materials used to control seepage losses in farm ponds, which is generally considered the most cost-effective and functionally durable in expansive clay soils?
(A) Highly porous geo-textiles without chemical treatment
(B) Uncompacted local sandy loam soil
(C) Untreated organic straw mats
(D) High-density polyethylene (HDPE) geomembranes

2005

19. Seed hardening is a prominent precision agronomy technique in drylands. What does this process fundamentally entail?
(A) Subjecting seeds to soaking-drying cycles to induce physiological stress tolerance
(B) Coating the seed coats with a thick layer of paraffin wax to completely halt imbibition
(C) Genetically modifying the cellular seed coat structure to resist all soil-borne pathogens
(D) Storing dormant seeds at sub-zero temperatures for prolonged periods to break deep dormancy

2014

20. Match List I with List II and select the correct answer.
List I: Climatic Classification System
P. Thornthwaite
Q. Koppen
R. Troll
S. Hargreaves
List II: Foundational Criteria
1. Temperature and vegetation zones
2. Number of humid months
3. Precipitation and potential evapotranspiration balance
4. Moisture Availability Index (MAI)
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-4, Q-1, R-2, S-3

2019

21. Foliar application of specific nutrients is highly recommended under dryland conditions. Which compound is frequently applied not only as a nitrogen source but also for its osmotic regulatory functions?
(A) Thiourea
(B) Calcium carbonate
(C) Potassium chloride (KCl)
(D) Superphosphate

2011

22. In the hierarchical classification of watersheds in India, what is the defined area range for a micro-watershed?
(A) 1 to 10 hectares
(B) 10 to 100 hectares
(C) 100 to 1000 hectares
(D) 1000 to 10000 hectares

2006

23. Which of the following is an INCORRECT statement regarding the application of fertilizers in dryland agriculture?
(A) Deep placement of basal fertilizers minimizes losses and ensures availability in the moist root zone
(B) Broadcast application of nitrogenous fertilizers on dry surface soil maximizes nutrient use efficiency
(C) Top-dressing of nitrogen is ideally synchronized with the receipt of rainfall
(D) Split application of nutrients is preferred to avoid heavy investment risks under uncertain rainfall

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2003

24. Which aridity index incorporates both the precipitation deficit and surplus in relation to water need to define the climatic boundaries of a region?
(A) Troll's Index
(B) Hargreaves' Moisture Availability Index
(C) Thornthwaite's Moisture Index
(D) De Martonne's Aridity Index

2012

25. Consider the following statements regarding drought indices and classifications:
I. Agricultural drought occurs when soil

I. Phenyl Mercuric Acetate is an effective film-forming antitranspirant.
II. Cycocel (CCC) restricts vegetative growth and helps the plant survive moisture stress.
III. Reflectants increase the heat load on the leaf surface, thereby promoting evaporation.
IV. Silicone-based oils act as film-forming antitranspirants.

Which of the statements given above are correct?
(A) I and II
(B) II and III
(C) II and IV
(D) III and IV

2014

73. Which of the following accurately describes the principle of aqua-fertigation in the context of precision dryland agronomy?
(A) Broadcasting dry fertilizer pellets from aircraft over extensive, un-irrigated rainfed crop areas
(B) Submerging the entire agricultural field in nutrient-rich water during the early pre-monsoon phase
(C) Cultivating aquatic nitrogen-fixing ferns in standard farm ponds to enrich irrigation water supply
(D) Delivering targeted liquid nutrients to the root zone with life-saving irrigation

2018

74. Match List I with List II and select the correct answer.

List I: Watershed Term
P. Catchment area
Q. Mini-watershed
R. In-situ moisture conservation
S. Check dam

List II: Description
1. Area ranging from 10 to 100 hectares
2. The entire geographical land area draining into a common designated outlet
3. Gully control structure to reduce flow velocity
4. Practices like contour bunding and BBF

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-1, S-3

2021

75. In agricultural drought assessment, what specific physiological consequence defines the "drought syndrome" in a susceptible crop?
(A) Enhanced synchronous tillering of lateral buds under high nitrogen inputs
(B) Severe wilting, impaired cell division, and disrupted development
(C) Accelerated grain filling rates resulting in abnormally large seeds at harvest
(D) Increased genetic resistance to all known piercing-sucking insect pests

2010

76. Which of the following is an INCORRECT statement regarding the application of mulches in dryland farming?
(A) Organic stubble mulches enhance earthworm activity and soil structure over time
(B) Clear plastic mulches are used to cool the soil surface in peak summer
(C) Dust mulching disrupts capillary water rise, thereby significantly reducing soil evaporation
(D) Organic mulches generally suppress weed emergence by physically blocking incoming solar sunlight

2022

77. Socio-economic drought is a unique classification. What fundamental dynamic must occur for a drought to be classified as socio-economic?
(A) Water shortage affects economic goods supply and societal well-being
(B) The total annual precipitation falls below two hundred millimeters for three consecutive years
(C) All major river systems in a continent run completely dry simultaneously during the summer
(D) The soil moisture tension reaches the permanent wilting point across an entire agricultural state

2024

78. Which institutional framework was established in 1985 in Hyderabad as the nodal agency for dryland agricultural research and technology transfer in India?
(A) ICAR-CAZRI
(B) ICRISAT
(C) ICAR-CRIDA
(D) AICRPDA

2001

79. When designing a rainwater harvesting farm pond in a highly permeable sandy soil, which intervention is absolutely critical for its functional success?
(A) Ensuring the excavated farm pond has a

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2005

49. Which of the following describes a key advantage of utilizing contour farming in sloping dryland topographies?
(A) It accelerates surface runoff velocity safely out of the agricultural watershed
(B) It creates small barriers that intercept runoff to increase infiltration
(C) It standardizes the length of crop rows for easier mechanized farming and harvesting
(D) It actively draws sub-surface groundwater to the surface layer via capillary action

2007

50. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): The application of reflectant type antitranspirants like kaolin lowers the leaf temperature of dryland crops.
Reason (R): Reflectants actively block stomatal pores, forcing the plant to transpire more efficiently.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2008

51. In the context of mid-season weather aberrations, which event defines an "early withdrawal" of the monsoon?
(A) Cessation of rainfall well before crop physiological maturity
(B) A ten-day continuous dry spell occurring immediately after seed germination
(C) The premature arrival of highly intense pre-monsoon showers in early April
(D) Continuous heavy rain events extending deep into the post-harvest period

2016

52. Which soil property primarily determines the effectiveness of compartmental bunding in retaining in-situ moisture?
(A) Electrical conductivity of the soil solution
(B) Total cation exchange capacity of clay minerals
(C) Infiltration rate and topography
(D) Base saturation percentage of the exchange complex

NODIA

2022

53. Under the classification of crop adaptation, deeply penetrating root systems that extract moisture from deeper soil horizons are a classic example of:
(A) Drought avoidance
(B) Drought tolerance
(C) Osmotic adjustment
(D) Drought escape

2008

54. Consider the following statements concerning watershed management components:
I. A milli-watershed ranges from 1000 to 10000 hectares.
II. Check dams are primarily intended for deep underground aquifer storage over decades.
III. Agri-silviculture is an alternate land use system suitable for marginal watershed lands.
IV. Dryland horticulture is strictly avoided in IWMP due to high water requirements.
V. Soil and water conservation measures form the foundational tier of any IWMP.
Which of the statements given above are correct?
(A) I, II, III and V
(B) I, III, IV and V
(C) II, III and V
(D) I, III and V

2021

55. Which of the following is considered a primary climatic constraint specifically characterizing the semi-arid drylands of India?
(A) Consistently low potential evapotranspiration rates throughout the year
(B) High variation in annual rainfall distribution
(C) Complete physical absence of active solar radiation during growing seasons
(D) Persistent severe winter frost events completely damaging the kharif crops

2009

56. What is the fundamental difference between tie-ridging and standard ridge-and-furrow cultivation in moisture conservation?
(A) Tie-ridging involves covering the soil ridges entirely with synthetic plastic mulch
(B) Tie-ridging aligns the agricultural furrows perfectly parallel to the maximum slope
(C) Tie-ridging blocks furrows with earth ties to prevent lateral runoff
(D) Tie-ridging requires continuous mechanical irrigation along the top of soil ridges

(C) Constructing large-scale concrete irrigation canals
(D) Agri-silvi-pasture and silvi-pasture systems

2007
87. Under the Koppen climatic classification, which specific variables are primarily integrated to define arid and semi-arid boundaries?
(A) Potential evapotranspiration rates and total soil profile depth
(B) Mean temperature and precipitation
(C) Wind velocity vectors and atmospheric barometric pressure zones
(D) Relative humidity percentages and solar radiation intensity values

2001
88. Consider the following statements regarding drought types and definitions:
I. Hydrological drought usually lags behind meteorological and agricultural droughts.
II. Agricultural drought occurs exclusively when surface water reservoirs dry up.
III. Meteorological drought is strictly defined as a statistically significant deficit in expected precipitation over a region.
Which of the statements given above are INCORRECT?
(A) I only
(B) I and III
(C) II only
(D) II and III

2011
89. Which physiological process is most directly impeded by the application of Cycocel (CCC) as a growth retardant in dryland crops?
(A) Photosynthetic electron transport chain in photosystem II
(B) Active transport of nitrate ions across the root endodermis
(C) Synthesis of abscisic acid (ABA) in root tips
(D) Cell elongation and excessive vegetative shoot extension

2015
90. Match List I with List II and select the correct answer.
List I: Mid-season Correction Strategy
P. Crop thinning
Q. Life-saving irrigation
R. Sowing short-duration alternative crops
S. Harvesting early for fodder
List II: Aberrant Weather Situation
1. Delayed onset of monsoon
2. Prolonged mid-season dry spell
3. Extreme early withdrawal of monsoon
4. Critical growth stage subjected to severe moisture stress
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-1, Q-4, R-2, S-3
(D) P-2, Q-3, R-1, S-4

2012
91. In dryland precision agronomy, determining the optimal sowing window is critical. Which analytical tool provides the most robust scientific basis for this decision?
(A) Analyzing the lunar phases to determine gravitational soil water pull
(B) Utilizing rainfall probability analyses and LGP mapping
(C) Consulting the historical wholesale market prices of the intended crop
(D) Estimating the potential yield of irrigated crops in neighboring districts

2005
92. Why is potassium (K) fertilization, often via foliar spray like KCl, emphasized during moisture stress in dryland agriculture?
(A) Potassium physically coats the leaves, acting as a highly efficient natural reflectant
(B) Potassium regulates turgor pressure and stomatal opening and closing
(C) Potassium permanently breaks deep seed physiological dormancy in dry, non-irrigated soils
(D) Potassium directly replaces nitrogen as the primary building block of crop leaf chlorophyll

2025
93. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Minimum or zero tillage is widely recommended under conservation agronomy in dryland areas.
Reason (R): Minimum tillage preserves crop residue on the surface, which significantly reduces evaporative water loss and moderates soil temperature.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)

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(C) It helps maintain cell turgor, which is crucial for stomatal functioning and metabolic processes
(D) It inherently prevents the generation of all Reactive Oxygen Species (ROS) during stress

2022

147. What is the precise definition of a "sub-watershed" based on the standard area classification adopted in Indian watershed management programs?
(A) An area encompassing 10,000 to 50,000 hectares
(B) An area encompassing 10 to 100 hectares
(C) An area encompassing 100 to 1,000 hectares
(D) An area encompassing 1,000 to 10,000 hectares

2004

148. Match the agronomic interventions in List I with their primary functional objectives under dryland conditions in List II:

List I: Agronomic interventions
P. Ratooning
Q. Dust mulching
R. Seed hardening
S. Split application of N

List II: Primary functional objectives
1. Interrupting capillary water rise to reduce evaporation
2. Inducing early physiological drought resilience in seedlings
3. Salvaging a severely stunted main crop to utilize late rains
4. Optimizing fertilizer use efficiency in response to uncertain rainfall

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-1, R-4, S-3

2016

149. Determine the correct sequential arrangement of dryland climatic zones in order of increasing annual moisture availability (from most arid to most humid):
I. Dryland farming (semi-arid)
II. Rainfed farming (sub-humid to humid)
III. Dry farming (arid)
(A) II, I, III
(B) I, II, III
(C) III, I, II
(D) III, II, I

2010

150. Which of the following is an accurate definition of the "initial probability" parameter when using the Markov chain model for analyzing agricultural rainfall?
(A) The statistical probability of a given week being dry immediately following a highly intense wet week
(B) The total cumulative measured rainfall depth recorded during the very first week of the active monsoon
(C) The long-term statistical certainty that the entire seasonal monsoon system will fail to deliver rain
(D) The probability of receiving rainfall in a given week regardless of the preceding week's weather state

2015

151. Under extreme and prolonged mid-season drought stress, which physiological process usually fails last, ultimately marking the irreversible death of the plant?
(A) Active photosynthetic carbon fixation and carbon dioxide assimilation
(B) Basal cellular respiration and minimal cell membrane integrity maintenance
(C) Transpirational water loss and active stomatal conductance processes
(D) Cellular expansion, structural growth, and mitotic cell division

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2013

152. Consider the following statements concerning the selection criteria for dryland crop varieties:
I. Varieties should ideally possess high phenological plasticity to adapt to shifting LGP.
II. Deep and dense rooting systems are a highly desirable trait for moisture extraction.
III. Strict photo-sensitivity is preferred so the crop flowers only on a specific calendar date regardless of sowing time.
IV. High early seedling vigor helps in rapid canopy closure and reduced soil evaporation.
V. Varieties with exceptionally long maturity durations are always preferred to maximize absolute yield potential.

Which of the above statements are correct?
(A) I, II and IV
(B) I, III and V
(C) II, III and IV
(D) I, IV and V

S. Markov Chain Analysis

List II: Variables

1. Initial and conditional probabilities
2. Precipitation and PET curves intersecting
3. Water surplus, water deficit, and water need
4. Number of humid and dry months

(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-2, R-4, S-1
(C) P-3, Q-4, R-2, S-1
(D) P-1, Q-4, R-2, S-3

2015

101. Which specific component of the Integrated Watershed Management Programme (IWMP) focuses on generating sustainable alternative livelihoods and managing common property resources?

(A) Implementing alternate land use systems like silvi-pasture and horticulture
(B) Construction of massive multi-purpose river valley concrete dams for hydroelectricity
(C) Introduction of highly mechanized, deep-tillage contract farming systems for profit
(D) Mandatory and rapid eviction of all domestic livestock from designated watershed areas

2005

102. When an agronomist recommends a "replacement series" intercropping pattern in a dryland setting, what does this mathematically imply about the plant population?

(A) The total combined plant population density significantly and intentionally exceeds that of either sole crop
(B) The primary main crop is completely removed and physically replaced mid-season by the companion intercrop
(C) The companion intercrop is sown exclusively and sparsely in the empty uncultivated border alleys of fields
(D) Substituting a proportion of the main crop with the intercrop, keeping total density constant

2023

103. Which physiological mechanism best explains why proline accumulation is considered a valuable drought tolerance trait?

(A) Proline instantly converts into highly complex structural starch, rigidifying plant cell walls
(B) Proline acts as a compatible osmolyte, lowering osmotic potential to maintain turgor
(C) Proline physically blocks the stomatal apertures from the inside to halt transpirational loss
(D) Proline significantly and rapidly increases the overall transpirational surface area of leaves

2014

104. In contingency planning, if the monsoon is exceptionally delayed beyond the normal sowing window of traditional long-duration crops, the most appropriate scientific recommendation is:

(A) Increasing the recommended chemical fertilizer dose for the traditional crop to force accelerated growth
(B) Broadcasting the traditional seeds anyway and relying strictly on chemical defoliants later in the season
(C) Switching to short-duration, photo-insensitive crops that can mature within the shortened LGP
(D) Completely abandoning all agricultural activities and leaving the farm land entirely fallow for the year

NODIA

2006

105. Consider the following statements regarding the mechanisms to reduce evapotranspiration:

I. Weed control mechanically eliminates unnecessary transpirational water loss.
II. Organic mulches are ineffective at moderating extreme soil surface temperatures.
III. Shelterbelts reduce wind velocity, thereby decreasing the advective heat load and evaporative demand.
IV. Clear plastic mulches are primarily used in hot drylands to rapidly cool the soil profile.
V. Stubble mulching protects the soil from splash erosion while reducing evaporation.

Which of the statements given above are correct?

(A) I, II and IV
(B) II, III and V
(C) I, IV and V
(D) I, III and V

2014

106. Determine the correct sequential order of the fundamental phases of contingency crop planning implementation:

I. Assessing real-time weather data and identifying the specific aberration (e.g., delayed onset)
II. Executing the planned mid-season corrections or alternate crop sowings
III. Pre-positioning of appropriate short-duration seeds and necessary inputs

IV. Monitoring crop recovery and adjusting terminal harvest strategies

(A) I, III, II, IV
(B) III, I, II, IV
(C) I, II, III, IV
(D) III, II, I, IV

2014

107. What constitutes a primary advantage of practicing contour farming as an in-situ moisture conservation technique?

(A) It redirects all surface runoff into a single channel for safe and rapid disposal
(B) It creates miniature ridges and furrows across the slope to intercept and retain rainfall
(C) It entirely eliminates the requirement for any external chemical fertilizer applications
(D) It aligns all crop rows along the steepest slope to accelerate surface drainage processes

2001

108. Which specific climatic parameter must be inherently high for a region to be classified under severe dryland constraints, exacerbating the effects of low rainfall?

(A) Relative humidity
(B) Potential Evapotranspiration (PET)
(C) Barometric pressure
(D) Atmospheric carbon dioxide concentration

2001

109. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Deep tillage using subsoilers is sometimes recommended in specific dryland soils.

Reason (R): Subsoiling effectively shatters naturally occurring or traffic-induced hardpans, significantly improving deep root penetration and deeper moisture extraction.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

110. Identify the INCORRECT statement regarding the physiological effects of drought stress on crop grain filling.

(A) Severe moisture stress during anthesis typically results in pollen sterility and poor seed set
(B) Drought during grain filling accelerates leaf senescence, significantly truncating the filling phase
(C) Drought stress strictly enhances current photosynthate translocation, resulting in heavier grains
(D) Terminal drought forces plants to rely entirely on the remobilization of stored stem reserves

2001

111. Which institutional body was initiated in 1970 to establish a network of research centers representing diverse agro-climatic zones across India for localized dryland research?

(A) ICAR-Central Arid Zone Research Institute (CAZRI) based in Jodhpur
(B) International Center for Agricultural Research in the Dry Areas (ICARDA)
(C) National Rainfed Area Authority (NRAA) of the Ministry of Agriculture
(D) All India Coordinated Research Project for Dryland Agriculture (AICRPDA)

2012

112. In the design of runoff management structures, what is the primary structural difference that defines a check dam compared to a standard contour bund?

(A) Check dams are constructed strictly of living vegetative materials to promote environmental sustainability
(B) Check dams are exclusively used to store high volumes of clean drinking water for large municipal sectors
(C) Check dams are built across gullies to intercept channelized flow, while contour bunds span general slopes
(D) Check dams require no formal engineering plans, hydrological safety considerations, or spillway mechanisms

2001

113. Which of the following best defines "drought avoidance" as a plant adaptation strategy?

(A) The plant's capacity to survive severe internal cellular dehydration and resume normal physiological growth upon rewatering
(B) The plant's capacity to maintain high tissue water potential during soil moisture deficits using deep roots or low transpiration
(C) The plant's capacity to rapidly complete its entire lifecycle and produce speculative seeds before severe seasonal drought begins
(D) The plant's capacity to synthesize and

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release specialized root exudates to suppress and eliminate all surrounding weeds

2018

114. Consider the following statements concerning aridity and climate classifications:

I. An Aridity Index evaluates the degree of water deficiency in a given region.

II. Hargreaves classification entirely ignores potential evapotranspiration.

III. The Koppen system incorporates natural vegetation types as broad indicators of climatic boundaries.

Which of the above statements are correct?

(A) I and II

(B) I and III

(C) II and III

(D) I only

2019

115. What is the fundamental agronomic objective of applying a 2% urea spray during a prolonged mid-season dry spell in rainfed crops?

(A) To provide absorbable nitrogen bypassing dry roots, maintaining leaf greenness and aiding recovery after rain

(B) To chemically desiccate the lower leaves of the crop canopy and force the entire plant into immediate dormancy

(C) To lower the osmotic potential of the surrounding rhizosphere, allowing soil particles to retain water tightly

(D) To deposit a reflective chemical layer on upper leaves to significantly increase the albedo of the crop canopy

2001

116. Match the dryland constraints in List I with their corresponding specific examples in List II:

List I: Dryland constraints

P. Biophysical constraint

Q. Climatic constraint

R. Socio-economic constraint

S. Technological constraint

List II: Specific examples

1. High inter-annual rainfall variability
2. Lack of access to custom hiring centers for modern machinery
3. Inherent poor soil structural stability (crusting)
4. Non-availability of localized drought-resilient seed varieties

(A) P-3, Q-1, R-2, S-4

(B) P-1, Q-3, R-4, S-2

(C) P-3, Q-2, R-1, S-4

(D) P-2, Q-4, R-3, S-1

2021

117. In the context of dryland precision agronomy, which weed control strategy is most critical to ensuring that limited soil moisture is exclusively utilized by the crop?

(A) Controlling weeds mechanically or chemically during the critical crop-weed competition period

(B) Postponing all weeding activities until the primary crop has reached physiological maturity

(C) Allowing a dense understory of weeds to develop freely and serve as a moisture-retaining living mulch

(D) Broadcasting high rates of nitrogen fertilizer to enable the crop to outgrow weed competition naturally

2001

118. Which alternate land use system is most scientifically appropriate for severely degraded, shallow soils (Land Capability Classes V to VII) within a dryland watershed?

(A) Intensive high-density annual cultivation of food crops like maize and wheat

(B) Continuous monocropping of highly demanding, deep-rooted commercial cotton crops

(C) Large-scale commercial flooded rice cultivation using intensive irrigation methods

(D) Silvi-pasture systems establishing perennial hardy fodder trees and forage grasses

2014

119. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Deep-placed basal fertilizers exhibit higher nutrient use efficiency in drylands compared to surface broadcasting.

Reason (R): Deep placement physically prevents the fertilizer from rapidly volatilizing and ensures it remains in the moist sub-surface zone accessible to active roots.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

NODIA

2022

120. Identify the INCORRECT statement regarding the application of antitranspirants.

(A) Mobileaf is a commercially available film-forming antitranspirant

(B) Stomatal closing antitranspirants can inadvertently reduce crop photosynthetic rates

(C) Phenyl Mercuric Acetate (PMA) operates by physically reflecting incoming solar radiation

(D) The use of antitranspirants is generally limited by high cost and practical application challenges in extensive field crops

2008

121. According to rainfall probability analysis using the Markov chain model, what does the Moisture Availability Index (MAI) fundamentally quantify?

(A) The exact number of consecutive rainless days recorded during the active crop growing season

(B) The total concentration of active organic carbon in the topsoil layer relative to field capacity

(C) The vertical depth of the local groundwater table measured at the beginning of the kharif season

(D) The ratio of assured rainfall at a specific probability level to potential evapotranspiration

2002

122. Which physiological component is most directly protected by a plant's ability to achieve osmotic adjustment during severe drought?

(A) Cellular turgor pressure, which is crucial for cell expansion and metabolic activity

(B) The structural thickness of protective cuticular wax layers on mature crop leaves

(C) The physical structure of lignified water-conducting xylem vessels in the stem

(D) The rapid physiological shedding of primary reproductive organs under moisture stress

2024

123. Consider the following statements concerning the historical framework of dryland research:

I. The Dry Farming Research Stations established in 1933 were located in Rohtak, Sholapur, Bijapur, Raichur, and Bellary.

II. ICRISAT's primary mandate focuses exclusively on temperate crops like wheat and barley.

III. CRIDA coordinates the AICRPDA network across India.

IV. CAZRI focuses primarily on the management of arid ecosystems and desertification.

Which of the above statements are correct?

(A) I, II and III

(B) I, III and IV

(C) II, III and IV

(D) I and IV

2023

124. In a dryland farming system receiving 850 mm of highly erratic annual rainfall, which overarching cropping strategy provides the greatest resilience against complete crop failure?

(A) Growing a single long-duration, high-yielding hybrid variety across the entire cultivation area

(B) Using a diverse intercropping system with crops of different rooting depths and growth durations

(C) Relying solely on wild, unmanaged weed growth for livestock fodder instead of sowing food crops

(D) Raising tender seedlings in nursery beds and transplanting them into the field mechanically

2007

125. What is the primary functional difference between a traditional contour bund and a Broad Bed and Furrow (BBF) system?

(A) Contour bunds are field-intercepting barriers, while BBF is an in-field raised bed balancing moisture and drainage

(B) Contour bunds facilitate rapid surface drainage, while BBF systems are designed to purely impound standing water

(C) Contour bunds are completely lined with synthetic plastics, while BBF systems are permanently sealed with concrete

(D) There is no distinct functional difference between these systems, as both terms represent identical regional synonyms

2007

126. Match the farm pond lining materials in List I with their primary operational characteristics or drawbacks in List II:

List I: farm pond lining materials

P. Natural clay puddling

Q. High-density polyethylene (HDPE)

R. Soil-cement mixture

S. Untreated sandy loam

List II: Operational characteristics or drawbacks

1. Highly durable, extremely low seepage, high

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initial cost
2. Requires precise compaction and curing, prone to cracking
3. Extremely high seepage rate, highly inefficient for water storage
4. Low cost, moderately effective only if inherently rich in expansive montmorillonite

(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-4, R-1, S-3

2010

127. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Thiourea is often utilized as a foliar spray in rainfed crops experiencing drought stress.
Reason (R): Thiourea acts as a powerful broad-leaf herbicide, eliminating weed competition instantly.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

128. Identify the INCORRECT statement regarding the implementation of contingency crop planning.
(A) Contingency plans are pre-formulated, reactive strategies deployed when standard weather expectations fail
(B) In the event of early monsoon withdrawal, harvesting the crop early for fodder is a recognized salvage strategy
(C) Mid-season corrections are generally rigid and cannot be altered regardless of subsequent rainfall events
(D) Alternate crop choices in contingency planning almost always prioritize short-duration and drought-hardy characteristics

2014

129. Which mathematical parameter is absolutely essential for calculating the Length of Growing Period (LGP) using the FAO methodology?
(A) The exact daily atmospheric pressure
(B) The ratio of precipitation to potential evapotranspiration over time
(C) The total number of cloudy days during the vegetative phase
(D) The historical frequency of socio-economic droughts in the region

2011

130. Determine the correct sequential order of water movement in an ideal macro-watershed system, from initial rainfall reception to final integrated storage:
I. In-situ infiltration within the micro-catchment
II. Flow through localized drainage lines and gullies
III. Reception of precipitation across the geographical catchment area
IV. Interception by gully plugs and check dams
V. Final accumulation in the terminal reservoir or macro-percolation tank

(A) III, I, II, IV, V
(B) I, III, II, IV, V
(C) III, II, I, IV, V
(D) III, I, IV, II, V

NODIA

2015

131. Which biophysical soil constraint is most commonly associated with the highly weathered alfisols typically found in semi-arid Indian drylands?
(A) Extreme waterlogging and poor subsurface drainage
(B) Poor moisture retention capacity and severe surface crusting
(C) High inherent soil organic carbon exceeding 2.5%
(D) Excessive accumulation of sodium carbonate creating alkaline hardpans

2005

132. In the context of dryland fertilizer management, why is synchronizing nitrogen top-dressing strictly with rainfall events considered a fundamental principle?
(A) Nitrogen fertilizers act as highly destructive chemical desiccants if they are applied directly onto wet crop leaves
(B) Rainwater chemically interacts with commercial urea to immediately transform it into highly stable organic matter
(C) Adequate soil moisture is necessary for the dissolution, movement, and efficient root uptake of applied nitrogen
(D) Applying fertilizer granules directly to dry soils acts as an effective physical buffer to reduce soil temperature

(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2023

94. What is the defining characteristic of a "macro-watershed" according to standard Indian watershed classifications?
(A) It encompasses an area of less than 100 hectares
(B) It encompasses an area ranging from 1,000 to 10,000 hectares
(C) It encompasses an area ranging from 10,000 to 50,000 hectares
(D) It encompasses a vast area exceeding 50,000 hectares

2021

95. Consider the following statements concerning rainwater harvesting and recycling:
I. Farm ponds in vertisols generally require expensive synthetic lining due to high natural percolation rates.
II. Supplemental irrigation using harvested water is most effectively applied during moisture-sensitive critical growth stages.
III. Catchment area treatment (CAT) reduces the silt load entering the harvesting structure.
IV. Open farm ponds completely eliminate evaporation losses.
Which of the statements given above are correct?
(A) I, II and IV
(B) I and III
(C) II, III and IV
(D) II and III

2009

96. Which of the following best describes the physiological basis of "seed hardening" prior to sowing in drylands?
(A) The physical abrasion of the outer seed coat to enhance rapid water entry under dry conditions
(B) Treating dormant seeds with concentrated sulfuric acid to kill all seed-borne pathogen species
(C) Pre-sowing hydration-dehydration cycles enabling seeds to withstand drought
(D) Coating seeds with heavy metals and chemical repellents to prevent consumption by soil rodents

2019

97. In the context of soil moisture conservation, what is the specific function of a "tie" in a tie-ridging system?
(A) It permanently connects two adjacent agricultural furrows to form a continuous irrigation canal system
(B) It acts as an earthen block in the furrow to prevent lateral runoff
(C) It is a vegetative barrier of deep-rooted perennial grasses planted strictly along the soil ridges
(D) It physically ties the tall crop stems together to prevent severe mechanical lodging under strong winds

2009

98. Which dryland constraint is broadly categorized as a socio-economic factor rather than a biophysical or climatic one?
(A) Consistently high potential evapotranspiration rates during the active kharif crop season
(B) Inherent extremely low organic matter content and poor nitrogen availability in soil alfisols
(C) Highly erratic and localized convective rainfall storm events across a geographic region
(D) Limited access to credit and high cost of critical inputs

2018

99. Identify the INCORRECT statement regarding the application of antitranspirants in practical dryland agriculture.
(A) They are highly cost-effective and universally recommended for low-value cereals
(B) Stomatal closing types can significantly and irreversibly reduce the net rate of leaf photosynthesis
(C) Film-forming types create a semi-permeable physical barrier to outward water vapor gas diffusion
(D) They are most practically utilized in high-value horticulture or micro-nurseries during stress periods

2025

100. Match List I with List II and select the correct answer.
List I: Aridity Index / Classification
P. Thornthwaite Index
Q. Troll's Classification
R. LGP Determination

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2025

140. Which specific type of precision agronomy technique involves deliberately sowing seeds in completely dry soil several days or weeks before the anticipated onset of the monsoon?
(A) Seed priming
(B) Dry seeding
(C) Seed pelleting
(D) Aqua-sowing

2002

141. Under severe moisture stress, what is the primary detrimental effect of stomatal closure on overall crop physiology?
(A) It restricts the influx of atmospheric CO_2, causing a rapid decline in photosynthetic carbon assimilation
(B) It accelerates the upward capillary movement of toxic dissolved soil salts directly into sensitive crop leaves
(C) It causes the immediate physical rupture of the root endodermis tissue due to high backward hydrostatic pressure
(D) It excessively cools outer leaf surface layers, causing severe chilling injury in sensitive tropical crops

2022

142. Consider the following statements concerning in-situ moisture conservation:
I. Compartmental bunding divides the field into small, square or rectangular plots to uniformly hold rainwater.
II. Contour farming requires all plowing and sowing operations to be conducted exactly parallel to the maximum slope gradient.
III. BBF systems are highly effective in deeply cracking vertisols for managing both moisture and drainage.
IV. Tie-ridging is strictly a runoff disposal mechanism and does not conserve moisture.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

2002

143. Which of the following is considered a primary advantage of utilizing organic or stubble mulches compared to synthetic plastic mulches in traditional dryland farming?
(A) Organic mulches provide complete and permanent reflection of all incoming solar radiation to keep the rhizosphere cool
(B) Organic mulches are entirely sterile and successfully guarantee the absolute elimination of all soil-borne pathogens
(C) Organic mulches heat the sub-surface soil profile much faster than transparent synthetic clear plastics during winter
(D) Organic mulches gradually decompose, improving soil organic carbon, aggregate stability, and overall soil health

2019

144. In a micro-watershed development project, what is the hierarchical functional placement of soil and water conservation measures?
(A) They are implemented exclusively after all long-term alternate land use systems have successfully reached full maturity
(B) They are treated as strictly optional measures and are only recommended if a substantial surplus budget remains available
(C) They are foundational, first-tier interventions required before establishing any advanced agronomic or horticultural activities
(D) They are executed exclusively on completely flat, highly fertile, and intensively irrigated lowland agricultural areas

2021

145. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The Moisture Availability Index (MAI) is a critical parameter in determining optimal cropping patterns in drylands.
Reason (R): MAI integrates the probability of receiving assured rainfall with the localized evaporative demand, providing a realistic measure of water adequacy for crops.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

146. Identify the INCORRECT statement regarding the physiological mechanism of drought tolerance through osmotic adjustment.
(A) Osmotic adjustment involves the active accumulation of solutes like proline and soluble sugars within the plant cells
(B) It lowers the cellular osmotic potential, enabling the plant to continue extracting water from increasingly dry soil

NODIA

2022

133. Which of the following defines "meteorological drought" according to standard climatic classifications?

(A) A state where annual crop yields drop below half of the decadal average specifically due to localized pest attacks

(B) A period where major regional hydroelectric dams and reservoirs are completely unable to generate electrical power

(C) A localized, temporary event where the measured soil moisture tension exceeds fifteen bars for a single afternoon

(D) A prolonged period of statistical deficiency in precipitation relative to the long-term regional expected average

2001

134. Which of the following indices is defined as the ratio of actual evapotranspiration to potential evapotranspiration, indicating the degree of moisture adequacy for crop growth?

(A) Index of Moisture Adequacy (IMA)

(B) Moisture Deficit Index (MDI)

(C) Aridity Index (AI)

(D) Crop Water Stress Index (CWSI)

2018

135. What is the fundamental principle behind utilizing "reflectants" in dryland agriculture?

(A) Spreading highly reflective mirrors across empty fields to redirect direct sunlight into the lower crop canopy layers

(B) Applying materials like kaolin to increase leaf albedo, reducing radiation load, leaf temperature, and transpiration

(C) Coating crop seeds with fluorescent dyes to ensure rapid and uniform germination under low-light field conditions

(D) Applying dark charcoal ash to absorb solar radiation and heat the shallow soil profile rapidly during cold mornings

2001

136. Which alternate land use system is structurally defined by the deliberate, simultaneous cultivation of arable agricultural crops alongside woody forest or fruit tree species?

(A) Silvi-pasture

(B) Agri-silviculture

(C) Horti-pasture

(D) Ley farming

2022

137. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Cultivating short-duration ephemeral crops is an excellent strategy for regions with an extremely short LGP.

Reason (R): Ephemerals exhibit extensive osmotic adjustment mechanisms allowing them to tolerate extreme dehydration for months.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

2021

138. Identify the INCORRECT statement regarding the calculation and application of aridity indices.

(A) Aridity indices help delineate the geographical boundaries between arid, semi-arid, and sub-humid climatic zones

(B) Thornthwaite's moisture index incorporates calculations of water surplus and water deficit

(C) Troll's climatic classification defines a semi-arid region strictly based on having 12 continuous humid months

(D) Aridity indices are vital tools for macro-level agricultural planning and policy formulation

2003

139. Match the drought types in List I with their primary operational indicators in List II:

List I: Drought types

P. Meteorological Drought

Q. Agricultural Drought

R. Hydrological Drought

S. Socio-economic Drought

List II: Primary operational indicators

1. Supply and demand imbalance of economic goods due to water shortage
2. Depletion of streamflows, groundwater, and reservoir levels
3. Significant negative deviation from long-term mean precipitation
4. Soil moisture deficit leading to severe crop stress and yield loss

(A) P-3, Q-4, R-2, S-1

(B) P-4, Q-3, R-2, S-1

(C) P-3, Q-1, R-4, S-2

(D) P-2, Q-4, R-3, S-1

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2025

153. What is the fundamental agronomic mechanism by which reducing tillage (conservation tillage) aids in managing dryland moisture constraints?
(A) It deeply shatters the dense subsoil horizons, directly creating massive underground storage reservoirs
(B) It completely exposes the bare soil surface, allowing rapid, direct absorption of atmospheric morning dew
(C) It instantly destroys all deep-rooted perennial weeds without the requirement of any chemical herbicides
(D) It minimizes soil inversion, keeping moisture within the profile and preserving protective residue cover

2005

154. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Check dams are highly effective in modifying the local micro-climate to mimic a humid tropical rainforest.
Reason (R): Check dams primarily function to trap sediment and enhance the localized recharge of the groundwater aquifer.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

155. Identify the INCORRECT statement regarding the application of foliar nutrients in dryland farming.
(A) Foliar application bypasses the dry topsoil where root nutrient uptake is severely restricted
(B) Foliar sprays can completely substitute the entire basal fertilizer requirement of a high-yielding crop
(C) Urea and KCl are commonly utilized as foliar sprays during dry spells
(D) Nutrients applied as foliar sprays are generally rapidly absorbed directly through the leaf cuticle and stomata

2003

156. Which specific type of water harvesting structure is primarily designed to impound surface runoff over a highly permeable localized area explicitly for the purpose of rapidly replenishing the underlying groundwater aquifer?
(A) Elevated concrete tank
(B) Percolation tank
(C) High-density lined farm pond
(D) Inter-row compartmental bund

2012

157. Match the institutional research milestones in List I with their primary mandated geographic or functional focus in List II:
List I: Institutional research milestones
P. CAZRI
Q. ICRISAT
R. AICRPDA
S. Dry Farming Research Stations (1933)
List II: Geographic or functional focus
1. Semi-arid tropics globally
2. Initial systematic moisture conservation experiments in India
3. Desertification and arid zone management
4. Pan-India coordinated localized dryland research network
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

2013

158. In the evaluation of rainfall data for dryland planning, why is the concept of "dry spell frequency" during the monsoon considered often more critical than the absolute total seasonal rainfall?
(A) Because total seasonal rainfall volume remains virtually identical across all diverse semi-arid agro-climatic farming regions
(B) Because high-intensity storm events consistently provide much more effective subsoil moisture than long, gentle, low-volume drizzles
(C) Because dry spells at critical growth stages cause irreversible physiological damage and yield loss, despite adequate total seasonal rain
(D) Because dry spell occurrences directly dictate the precise international market pricing models of the harvested agricultural commodity

2024

159. Which of the following best explains the specific mechanism of action for a "film-forming" antitranspirant?
(A) It triggers biochemical signals within the

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2009

172. Identify the INCORRECT statement regarding the application and function of growth retardants like Cycocel (CCC) in managing drought stress.
(A) Cycocel significantly reduces excessive vegetative shoot elongation
(B) Cycocel acts as a powerful defoliant, instantly stripping the plant of all functional leaves
(C) By restricting shoot growth, Cycocel often favorably alters the root-to-shoot ratio
(D) Cycocel application can help conserve limited soil moisture by reducing the overall transpirational surface area

2002

173. What is the defining characteristic of a "mini-watershed" according to standard Indian area classifications?
(A) An area typically ranging from 10 to 100 hectares
(B) An area typically ranging from 1 to 10 hectares
(C) An area typically ranging from 100 to 1,000 hectares
(D) An area typically ranging from 1,000 to 10,000 hectares

2025

174. Match the water harvesting and management techniques in List I with their primary functional descriptions in List II:

List I: Water harvesting and management techniques
P. Broad Bed and Furrow (BBF)
Q. Farm pond lining
R. Life-saving irrigation
S. Compartmental bunding

List II: Primary functional descriptions
1. Minimizing seepage losses through materials like HDPE
2. A targeted minimal water application during critical stress stages
3. In-situ moisture conservation primarily on flat, sloped fields
4. A raised bed layout managing both in-situ moisture and safe runoff disposal

(A) P-4, Q-1, R-2, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-1, Q-4, R-2, S-3
(D) P-4, Q-2, R-1, S-3

2018

175. Which drought adaptation mechanism primarily involves the plant's ability to maintain a high internal tissue water potential despite a significant deficit in soil moisture, typically achieved through specialized traits like extensive deep rooting or thick cuticular wax?
(A) Drought escape
(B) Osmotic adjustment
(C) Drought recovery
(D) Drought avoidance

2022

176. In contingency crop planning for an extreme mid-season prolonged dry spell where crop failure appears imminent, what is the most appropriate salvage strategy?
(A) Instantly applying heavy chemical doses of basal diammonium phosphate fertilizer
(B) Deep plowing the entire agricultural field while the cash crop is still standing
(C) Harvesting the stunted standing crop immediately to utilize as livestock fodder
(D) Constructing a massive concrete check dam system directly within active crop rows

2006

177. Which mathematical or statistical model is most widely utilized in dryland agro-meteorology to calculate the probability of specific sequences of wet and dry weeks occurring during the monsoon?
(A) The universal soil loss equation
(B) The Markov chain probability model
(C) The Penman-Monteith equation
(D) The quadratic yield response function

2009

178. Consider the following statements concerning the mitigation of evapotranspiration:
I. Synthetic clear mulches are highly effective in reducing soil evaporation but may excessively heat the topsoil.
II. Stomatal closing antitranspirants effectively increase both transpiration and photosynthesis simultaneously.
III. Windbreaks and shelterbelts reduce the advective energy load, thereby decreasing regional evapotranspiration.
IV. Organic mulches contribute to long-term soil structure improvement while conserving moisture.

Which of the above statements are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I and IV

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heavy metal residues in developing seed embryos

2001

166. Match the conservation agriculture components in List I with their primary agronomic effects in drylands in List II:

List I: Conservation agriculture components

P. Reduced tillage
Q. Crop residue retention
R. Contour farming
S. Dry seeding

List II: Primary agronomic effects

1. Utilizing early pre-monsoon showers for prompt establishment
2. Moderating soil temperature and significantly reducing evaporation
3. Intercepting and slowing the velocity of surface runoff across a slope
4. Preserving soil structure and macro-pores while saving operational energy

(A) P-4, Q-2, R-3, S-1
(B) P-2, Q-4, R-1, S-3
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-3, R-4, S-2

2003

167. Which of the following accurately describes the primary distinction between "dry farming" and "dryland farming" regarding the likelihood of crop failure?

(A) Dryland farming operations encounter continuous and highly destructive crop failures due to severe waterlogging
(B) Dry farming (< 750 mm) faces a higher crop failure frequency due to moisture deficits than dryland farming
(C) Dry farming methods essentially guarantee exceptionally high crop yields and profits every single cropping season
(D) There is absolutely no statistical or physical difference in the long-term risk profile between the two systems

2006

168. Determine the correct sequential progression of the physiological drought syndrome in a typical mesophytic crop experiencing sudden, severe moisture stress:

I. Complete loss of turgor and visible permanent wilting
II. Reduction in cell expansion and impaired leaf elongation
III. Extensive generation of ROS and onset of premature senescence
IV. Initial stomatal closure and decline in photosynthetic rate

(A) II, IV, I, III
(B) IV, II, I, III
(C) IV, I, II, III
(D) II, I, IV, III

2012

169. Consider the following statements concerning aridity and climatic indices:

I. The Moisture Availability Index (MAI) utilizes a 75% probability of assured rainfall.
II. Troll's classification relies heavily on determining the number of humid months.
III. Thornthwaite's moisture index ignores the role of potential evapotranspiration completely.
IV. The Koppen system assigns specific letter codes to define broad global climate classifications.

Which of the above statements are correct?

(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I, II and III

2014

170. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Deep-rooted crops like pigeonpea are inherently better suited for intercropping with shallow-rooted cereals in dryland systems.

Reason (R): Deep-rooted crops exclusively extract moisture from the upper 15 cm of the soil profile, outcompeting the shallow-rooted cereals.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2003

171. Which biophysical constraint is specifically associated with the rapid drying and subsequent hardening of the topsoil layer, which severely restricts seedling emergence in many semi-arid alfisols?

(A) Soil salinization
(B) Soil crusting
(C) Sub-surface hardpan formation
(D) Peat accumulation

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conservation structures
III. Selecting drought-tolerant crops and varieties prior to the season
IV. Harvesting the stunted crop prematurely strictly for livestock fodder
(A) II, III, I, IV
(B) III, II, I, IV
(C) II, I, III, IV
(D) I, II, III, IV

2009

186. Which of the following is considered a primary socio-economic constraint significantly limiting the productivity of traditional dryland agriculture?
(A) Fragmented landholdings and extreme resource poverty, limiting farmer investment and risk-taking
(B) A complete and permanent seasonal absence of solar radiation within tropical agricultural zones
(C) Excessive government subsidies that completely cover all purchase costs of heavy farm machinery
(D) Inherent and toxic concentrations of heavy metals distributed across all arid agricultural alfisols

2013

187. Consider the following statements concerning seed hardening and dry seeding techniques:
I. Seed hardening typically involves subjecting seeds to precise hydration and dehydration cycles to induce physiological resilience.
II. Dry seeding involves completely submerging seeds in water for a month before sowing.
III. Dry seeding is often practiced to capitalize on the very first pre-monsoon showers, ensuring rapid and uniform establishment.
IV. Hardened seeds generally exhibit faster and more vigorous germination under suboptimal moisture conditions compared to untreated seeds.
Which of the above statements are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I and IV

2022

188. Which alternate land use system is most appropriate for integrating natural fodder grass production with woody perennial trees on marginal watershed lands?
(A) Agri-silviculture
(B) Silvi-pasture
(C) Horti-pasture
(D) Intensive sole-cropping

2021

189. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cultivating long-duration, highly photoperiod-sensitive varieties is the best strategy for a region characterized by a highly erratic and short LGP.
Reason (R): Long-duration crops inevitably expose their sensitive reproductive stages to the highest probability of severe terminal drought.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

190. Identify the INCORRECT statement regarding the implementation of mid-season agronomic corrections.
(A) Crop thinning helps to match the remaining plant population with the severely depleted soil moisture reserves
(B) Weed control becomes even more critical during dry spells to prevent weeds from depleting the minimal available moisture
(C) Mid-season corrections are rigid and must be applied regardless of actual weather conditions once planned
(D) Life-saving irrigation targets the most critical physiological growth stage to maximize the impact of limited harvested water

NODIA

2024

191. What is the primary physiological function of the amino acid proline when it heavily accumulates in plant tissues during severe drought stress?
(A) It acts strictly as an essential structural biochemical component designed to heavily lignify the internal stem tissues
(B) It acts as a powerful leaf reflectant, physically altering and increasing the overall albedo of the leaf epidermal layer
(C) It rapidly and systematically degrades the green chloroplasts to completely stop all current photosynthetic activity
(D) It acts as a compatible osmolyte, facilitating osmotic adjustment and protecting sub-cellular structures from dehydration

2010

179. Which specific integrated watershed management component aims to safely intercept and reduce the high velocity of channelized surface runoff within drainage lines or gullies, thereby preventing severe soil erosion and promoting localized recharge?
(A) Construction of check dams and gully plugs
(B) Deep plowing of the upper ridge tops
(C) Widespread aerial broadcasting of urea
(D) Complete deforestation of the catchment area

2017

180. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Dryland precision agronomy heavily emphasizes strict adherence to optimal, and often very narrow, sowing windows.
Reason (R): Sowing strictly within the optimal window aligns the crop's most critical and sensitive growth stages with the period of highest historical rainfall probability and maximum LGP.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

181. Identify the INCORRECT statement regarding fertilizer application techniques in dryland environments.
(A) Surface broadcasting of urea on completely dry, hot soil is universally recommended as the most efficient application method
(B) Basal deep placement minimizes volatilization losses and positions nutrients in the moister subsoil zone
(C) Top-dressing of solid nitrogen should ideally be synchronized with active rainfall events to ensure dissolution and root uptake
(D) Split application is an effective strategy to manage financial risk by adjusting fertilizer doses based on actual rainfall receipts

2010

182. Which of the following defines "hydrological drought" in standard literature?
(A) A sudden, highly localized failure of monsoon rain systems during a single week of active crop growth in the month of July
(B) A prolonged, intense soil moisture deficit specifically causing severe permanent wilting in most upland agricultural crops
(C) A socioeconomic situation where baseline water supply remains completely adequate but general consumer demand suddenly doubles
(D) Inadequate precipitation leading to critical deficiencies in surface and sub-surface water resources like streams and reservoirs

2007

183. Under rainfed conditions, what is the primary physiological benefit of applying a foliar spray of Potassium Chloride (KCl) during a severe dry spell?
(A) It rapidly defoliates the crop canopy, completely halting any future transpirational water loss
(B) It supplies potassium to leaves, helping maintain turgor pressure and regulate stomatal behavior
(C) It forms a highly thick, impermeable physical polymeric film over the entire leaf surface
(D) It acts as a highly powerful reflectant, changing the leaf epidermal color to a brilliant white

2019

184. Match the historical institutions in List I with their corresponding establishment years in List II:
List I: Historical institutions
P. Dry Farming Research Stations (Rohtak, Sholapur, etc.)
Q. CAZRI
R. AICRPDA
S. ICRISAT
List II: Establishment years
1. 1959
2. 1933
3. 1972
4. 1970
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-1, S-3

2001

185. Determine the correct sequential order of the drought management hierarchy, starting from proactive planning to extreme reactive salvage:
I. Executing mid-season corrections (e.g., thinning) during a dry spell
II. Implementing long-term watershed and soil

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ANSWERS

1. (B) Cultivation of crops in areas receiving less than 750 mm annually
Dry farming is traditionally defined as the cultivation of crops in regions receiving an annual rainfall of less than 750 millimeters. These areas face acute moisture stress during the crop growth cycle, requiring strict conservation practices. In contrast, dryland farming occurs where rainfall ranges from 750 to 1150 millimeters, and rainfed farming exceeds this threshold.

2. (B) 1929
Systematic research on dryland agriculture in India began in 1933 with the establishment of five dry farming research stations under the Imperial Council of Agricultural Research. These stations were located in moisture-stressed regions including Rohtak, Solapur, Bijapur, Raichur, and Hagari. They aimed to develop location-specific soil and water conservation practices to mitigate crop failure.

3. (A) Severe surface crusting due to poor structural stability
Alfisols in dryland ecosystems are highly prone to surface crusting due to their low organic matter content and poor structural stability. When rainfall hits the bare soil, clay particles disperse and clog surface pores. Upon drying, a hard crust forms, which physically impedes seedling emergence and significantly reduces the infiltration rate of subsequent rainfall.

4. (C) The balance between precipitation and potential evapotranspiration
Thornthwaite's climatic classification system evaluates regional aridity using a moisture index derived from the balance between precipitation and potential evapotranspiration. This relationship accounts for both water surplus and water deficit relative to the climatic water demand. By comparing moisture supply with environmental demand, the system establishes precise boundaries for arid, semi-arid, and humid zones.

5. (A) V, II, IV, I, III
Watershed classification in India follows a strict hierarchical structure based on geographical area. The sequence progresses from the smallest unit to the largest system. Mini-watersheds represent the smallest category, followed by micro-watersheds, milli-watersheds, sub-watersheds, and finally macro-watersheds. This systematic categorization helps planners design and implement targeted soil and water conservation structures across different scales.

6. (D) The probability of a wet week occurring immediately after a dry week
Markov chain probability models in dryland agriculture analyze weather dependencies by evaluating conditional probabilities. This statistical approach measures the likelihood of a specific weather state occurring based on the state of the preceding period. Calculating the probability of a wet week following a dry week helps agronomists predict critical dry spells and plan crop sowing operations.

7. (B) 50 percent of potential evapotranspiration
The length of growing period is defined as the continuous period during the year when rainfall exceeds fifty percent of the potential evapotranspiration. This threshold represents the minimum moisture supply required to support active crop growth and transpiration. It also includes the time during which stored soil moisture can satisfy the remaining crop water requirements.

NODIA

8. (C) Hydrological drought
Hydrological drought is characterized by a significant depletion of surface and sub-surface water resources due to prolonged precipitation deficits. This type of drought manifests as reduced streamflows, falling water levels in lakes and reservoirs, and declining groundwater tables. It typically lags behind meteorological and agricultural droughts because hydrological systems react slowly to weather anomalies.

9. (D) Proline
Proline is an amino acid that accumulates rapidly in plant tissues in response to severe environmental stresses, particularly drought and salinity. It functions as a compatible osmolyte, facilitating cellular osmotic adjustment to

2016

192. Which aridity index or climatic classification specifically relies on calculating the explicit balance between precipitation and potential evapotranspiration to define regions as arid, semi-arid, or sub-humid?
(A) The Koppen Classification System
(B) The Universal Aridity Equation
(C) The Thornthwaite Moisture Index
(D) The Beaufort Scale

2022

193. Match the runoff management structures in List I with their most suitable topographic or functional application within a watershed in List II:

List I: Runoff management structures
P. Contour bunding
Q. Check dam
R. Percolation tank
S. Farm pond (lined)

List II: Topographic or functional application
1. Direct interception of channelized flow in gullies
2. Widespread in-situ moisture retention across mild, uniform slopes
3. Maximizing surface water storage for subsequent life-saving irrigation
4. Dedicated impoundment over permeable soils for deep aquifer recharge

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-3, R-1, S-2

2025

194. In the context of drought classification, which type of drought is fundamentally defined by the physical shortage of water beginning to directly impact the supply and demand of essential economic goods and human well-being?
(A) Meteorological drought
(B) Agricultural drought
(C) Hydrological drought
(D) Socio-economic drought

2014

195. Determine the correct sequential order of watershed sizes from the largest macro-scale down to the smallest micro-scale:
I. Mili-watershed
II. Macro-watershed
III. Micro-watershed
IV. Sub-watershed
V. Mini-watershed
(A) II, IV, I, V, III
(B) II, IV, I, III, V
(C) IV, II, I, III, V
(D) II, I, IV, III, V

2014

196. Consider the following statements concerning the application of mulches in dryland environments:
I. Dust mulching effectively breaks continuous capillary channels, significantly reducing sub-surface evaporation.
II. Organic stubble mulches moderate extreme soil temperature fluctuations and gradually improve soil organic carbon.
III. Black synthetic plastic mulches are highly recommended to rapidly cool the soil in hot tropical drylands.
IV. Mulches generally help suppress weed emergence, further conserving soil moisture.
V. Stubble mulches dramatically increase the impact velocity of raindrops, causing severe splash erosion.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and V
(C) I, III and IV
(D) I, II and V

2022

197. Which of the following is considered the most critical "biophysical" constraint affecting early crop establishment in crust-prone dryland alfisols?
(A) The rapid formation of a hard surface crust upon drying that physically impedes seedling emergence
(B) The high level of inter-annual and seasonal variation in total cumulative precipitation
(C) The absolute lack of farmer access to formal regional institutional banking and crop credit
(D) The excessively high inherent organic matter content causing extreme and sponge-like soils

2016

198. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Dryland agronomy strongly advocates for the cultivation of short-duration, drought-escaping varieties.
Reason (R): Short-duration varieties rapidly complete their entire reproductive cycle before the onset of the severe, predictable terminal dry

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guard cells to instantly close the functional stomatal pore apertures
(B) It aggressively and fully reflects all incoming solar photosynthetically active radiation away from upper leaf tissues
(C) It acts as a highly powerful cellular osmoticant, physically drawing and sequestering free water out of leaf tissues
(D) It forms a thin, semi-permeable polymeric barrier on leaves, increasing resistance to outward water vapor diffusion

2005

160. Consider the following statements concerning the Length of Growing Period (LGP):
I. LGP is identical to the total lifespan of a perennial tree.
II. The humid period within the LGP is characterized by precipitation exceeding full potential evapotranspiration.
III. In arid regions, the LGP is typically very short, strictly limiting crop choices.
IV. LGP models rely heavily on precise soil moisture holding capacity and historical climatic data.
Which of the above statements are correct?
(A) I and II
(B) II, III and IV
(C) I, III and IV
(D) II and IV

2008

161. What is the fundamental socio-economic objective integrated within modern watershed management programs alongside physical soil and water conservation?
(A) Maximizing the deployment of imported heavy industrial machinery to systematically displace manual agricultural labor forces
(B) Ensuring equitable resource sharing, generating alternate livelihoods, and fostering active community-led decision making
(C) Completely privatizing all common village grazing lands, local forests, and community-owned water harvesting ponds
(D) Forcing the total conversion of traditional subsistence crop farming into highly commercial, export-oriented floriculture

2007

162. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Intercropping systems in drylands generally exhibit a Land Equivalent Ratio (LER) greater than 1.0.
Reason (R): Intercropping spatially and temporally separates resource demands, allowing the combined crops to utilize available moisture and light more efficiently than a sole crop.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

163. Identify the INCORRECT statement regarding the application of mid-season agronomic corrections during aberrant weather.
(A) A 2% urea foliar spray is highly toxic and is strictly used as a chemical defoliant to end the crop cycle during a drought
(B) Crop thinning physically reduces the plant population, thereby lowering the cumulative transpirational demand on remaining soil moisture
(C) Ratooning allows certain resilient crops to regenerate productive tillers from the basal nodes upon the receipt of late rains
(D) Providing a life-saving irrigation from a harvested farm pond during the grain-filling stage can dramatically prevent total yield collapse

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2010

164. Which specific type of climatic classification system is widely recognized for defining climatic zones primarily based on the precise ratio of precipitation (P) to potential evapotranspiration (PET)?
(A) Koppen System
(B) Modified Hargreaves System
(C) Thornthwaite System
(D) Troll's System

2013

165. In the context of drought management, which physiological effect is most directly responsible for the "impaired grain filling" observed during terminal drought stress?
(A) The rapid onset of leaf senescence and severe limitation of current assimilate availability
(B) Excessive and uncoordinated physiological development of primary root hair systems
(C) Uncontrolled stomatal opening processes leading to extreme, fatal tissue hydration
(D) The excessive over-accumulation of toxic

destructive to all known beneficial groups of soil microbes

2022

205. Consider the following statements concerning fertilizer management in dryland agriculture:

I. Deep placement of basal fertilizer in the moist root zone is highly recommended.
II. Top-dressing of solid nitrogenous fertilizers should ideally coincide with periods of active rainfall.
III. Applying fertilizer to completely dry surface soil results in extremely high nutrient use efficiency.
IV. Split application strategies help farmers manage economic risk under highly uncertain rainfall conditions.
V. Foliar application of urea can be an effective method to rapidly supply nitrogen during a prolonged dry spell.

Which of the above statements are correct?

(A) I, II, IV and V
(B) I, III, IV and V
(C) II, III, IV and V
(D) I, II, III and V

2017

206. Which integrated watershed management component strictly involves the cultivation of fruit-bearing or commercial tree species specifically adapted to arid and semi-arid conditions?

(A) Agri-silviculture
(B) Silvi-pasture
(C) Dryland horticulture
(D) Deep-water aquaculture

2007

207. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Cultivating pure stands of high-yielding, long-duration hybrids is generally considered the safest and most reliable strategy in regions receiving less than 500 mm of highly erratic rainfall.

Reason (R): Long-duration crops have a growth duration that extends beyond the typical rainy season, making them highly vulnerable to terminal moisture stress.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

208. Identify the INCORRECT statement regarding the physiological processes involved in seed hardening.

(A) Seed hardening typically involves precise, controlled cycles of soaking and drying the seeds prior to sowing
(B) Hardened seeds often exhibit favorable physio-chemical alterations, allowing them to better withstand subsequent drought conditions
(C) The process generally results in a significant delay in field emergence and inherently weaker seedling vigor
(D) The technique is a prominent precision agronomy tool to ensure robust early establishment under suboptimal moisture

2006

209. What is the precise, standard definition of a "micro-watershed" within the context of Indian watershed management area classifications?

(A) An area typically encompassing less than 10 hectares
(B) An area typically encompassing 100 to 1,000 hectares
(C) An area typically encompassing 10 to 100 hectares
(D) An area typically encompassing 1,000 to 10,000 hectares

2007

210. Which primary agronomic principle governs the spatial design of an effective "replacement series" intercropping system in drylands?

(A) Simply mixing seeds of two distinct crops randomly before broadcasting them uniformly across the entire field area
(B) Planting the main crop at its full sole-crop density while adding the intercrop as an extra population in the same row
(C) Planting all intercrop seeds strictly along the outer field boundaries to act as a protective structural windbreak
(D) Replacing a calculated proportion of the main crop with the intercrop to balance density and resource use

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spell.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012
199. Identify the INCORRECT statement regarding the principles of contingency crop planning for a significantly delayed monsoon.
(A) The primary objective is to select alternate crops or varieties that can successfully mature within the newly shortened remaining LGP
(B) Farmers are advised to immediately increase the sowing density and fertilizer dosage of their traditional long-duration varieties
(C) Short-duration pulses or millets are frequently recommended as substitute crops
(D) Pre-positioning of alternate seed varieties by regional agricultural departments is critical for successful implementation

2021
200. Which of the following best describes the physiological basis of "drought syndrome" in a susceptible crop experiencing severe, unmitigated moisture stress?
(A) A sustained state of enhanced exponential vegetative growth, leaf expansion, and increased branch production
(B) The sudden hyper-accumulation of starch compounds in mature leaves, leading to complete tissue rigidification
(C) A cascade of failures including loss of turgor, stomatal closure, ceased cell expansion, and premature senescence
(D) The completely uninhibited, rapid functioning of all components of the photosynthetic electron transport chain

2014
201. What is the fundamental purpose of constructing a Broad Bed and Furrow (BBF) system in deeply cracking vertisols?
(A) To entirely prevent any volume of surface runoff water from leaving the field boundary under any circumstances
(B) To create a completely level, flat agricultural field strictly optimized for flooded wetland rice cultivation
(C) To concentrate all available soil profile moisture into a single, extremely deep central trench structure
(D) To balance conserving in-situ moisture during dry spells with providing safe surface drainage during heavy rains

2001
202. Match the types of antitranspirants in List I with their corresponding specific chemical examples in List II:
List I: Types of antitranspirants
P. Stomatal closing type
Q. Film-forming type
R. Reflectant type
S. Growth retardant
List II: Specific chemical examples
1. Cycocel (CCC)
2. Hexadecanol or Silicone oils
3. Phenyl Mercuric Acetate (PMA)
4. Kaolin powder
(A) P-3, Q-2, R-4, S-1
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-1, Q-2, R-4, S-3

2010
203. In analyzing rainfall probabilities for agricultural planning using the Markov chain model, what specifically does the "conditional probability" reveal?
(A) The absolute total cumulative volume of rainfall expected to occur over the course of an entire decade
(B) The likelihood of an event (like a wet week) given the state of the preceding period (like a dry week)
(C) The theoretical maximum possible crop yield achievable under completely perfect, unlimited irrigation
(D) The exact calendar date on which the seasonal monsoon winds will withdraw from the local territory

2012
204. Which of the following is considered a major disadvantage of utilizing stomatal-closing type antitranspirants in practical field crop production?
(A) They drastically increase and accelerate the overall rate of transpirational crop water loss
(B) They restrict stomatal opening, reducing CO_2 influx and thereby lowering photosynthesis and yield
(C) They chemically dissolve and degrade the protective cuticular wax layer on the leaf surfaces
(D) They are completely toxic and highly

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maintain cell turgor pressure. Additionally, proline protects subcellular structures, stabilizes membranes, and scavenges harmful reactive oxygen species generated during moisture stress.

10. (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
Ephemeral plants adapted to desert environments employ drought escape as their primary survival strategy. These short-lived species complete their entire life cycle rapidly during the brief periods when soil moisture is available. By germinating, flowering, and setting seed in a few weeks, they successfully produce viable seeds and avoid experiencing severe physiological drought stress altogether.

11. (B) Phenyl Mercuric Acetate (PMA)
Phenyl Mercuric Acetate is a well-known chemical that functions as a stomatal closing type of antitranspirant. When applied to foliage, it induces partial closure of stomatal pores, which significantly reduces the rate of transpiration. This mechanism helps plants conserve internal water during critical dry spells, although it may also limit carbon dioxide assimilation and photosynthesis.

12. (B) To revive physiological activity and enhance photosynthetic efficiency upon recovery
A foliar spray of two percent urea during a mid-season dry spell serves as an agronomic correction to revive physiological activity. Once rainfall occurs, this nitrogen application helps the canopy recover quickly by promoting rapid vegetative growth and enhancing photosynthetic efficiency. It assists the crop in recovering from drought-induced nutrient deficiencies and tissue damage.

13. (A) It removes transpiring biomass to allow basal regrowth upon subsequent rainfall
Ratooning is recommended as an emergency agronomic practice during severe, prolonged drought spells. By cutting back the stunted crop, farmers remove transpiring vegetative biomass that would otherwise exhaust remaining soil moisture. When subsequent rainfall occurs, the established root system utilizes the fresh moisture to support healthy, productive basal regrowth and secure a harvest.

14. (C) To provide biological insurance against total crop failure under erratic rainfall
Intercropping systems are widely practiced in dryland regions as a biological insurance policy against total crop failure. Cultivating companion crops with different growth habits, root depths, and maturity periods ensures that at least one crop will yield even under erratic rainfall. This practice maximizes land use efficiency and stabilizes farming income under highly unpredictable weather conditions.

15. (D) Broad Bed and Furrow (BBF), Compartmental bunding, Check dams, Percolation tanks
Soil moisture conservation techniques are implemented at different scales, progressing from field-level micro-catchments to macro-drainage lines. The Broad Bed and Furrow system and compartmental bunding are applied directly on cultivated fields to conserve in-situ moisture. Check dams are constructed along gullies to reduce runoff velocity, while percolation tanks are built at lower watershed points for groundwater recharge.

16. (C) It breaks capillary pore channels, interrupting upward movement of soil water
Dust mulch, or soil mulch, is created by shallow cultivation of the topsoil. This practice breaks the continuous capillary pore channels connecting the deeper, moist soil layers with the dry atmosphere. By interrupting this capillary rise, the upward movement of water is blocked, which significantly reduces evaporation losses and conserves vital sub-surface moisture for crop roots.

17. (B) To reduce runoff velocity, trap sediment, and recharge local groundwater
Check dams are small, semi-permanent barrier structures constructed across drainage lines or gullies. Their primary function is to reduce the velocity of surface runoff, which minimizes soil erosion and traps eroded sediment. By slowing down water flow and impounding runoff temporarily, check dams facilitate maximum infiltration, thereby enhancing localized groundwater recharge across the agricultural watershed.

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18. (D) High-density polyethylene (HDPE) geomembranes
High-density polyethylene geomembranes are highly effective and durable lining materials

for farm ponds constructed in expansive clay soils. These soils undergo severe swelling and shrinking cycles, which can crack rigid concrete linings. Flexible geomembranes withstand these structural movements, providing a continuous, impermeable barrier that almost completely eliminates seepage losses over long periods.

19. (A) Subjecting seeds to soaking-drying cycles to induce physiological stress tolerance
Seed hardening is a pre-sowing physiological treatment where seeds are subjected to repeated cycles of soaking in water or chemical solutions and then dried. This process triggers biochemical changes that prime the embryo, enhancing root development and cellular membrane integrity. Consequently, hardened seeds germinate more rapidly and exhibit superior tolerance to initial soil moisture stress.

20. (C) P-3, Q-1, R-2, S-4
Climatic classification systems utilize distinct foundational criteria to define aridity and moisture zones. Thornthwaite established his boundaries using the balance between precipitation and potential evapotranspiration. Koppen emphasized temperature and vegetation zones, while Troll categorized climates based on the number of humid months. Hargreaves developed the moisture availability index to assess agricultural water security.

21. (A) Thiourea
Thiourea is a sulfhydryl compound frequently applied as a foliar spray in dryland agriculture. Beyond providing nitrogen, it plays a vital role in osmotic regulation and antioxidant defense during periods of moisture stress. Thiourea application improves plant water status, protects photosynthetic machinery, and helps maintain active cell metabolism under adverse, drought-stressed environmental conditions.

22. (C) 100 to 1000 hectares
In the standardized hierarchical classification of watersheds in India, a micro-watershed is defined as an area covering one hundred to one thousand hectares. This intermediate scale is highly suitable for planning and implementing localized soil and water conservation treatments. It allows community-level participation and precise monitoring of hydrological interventions within the overall watershed management framework.

23. (B) Broadcast application of nitrogenous fertilizers on dry surface soil maximizes nutrient use efficiency
Applying nitrogenous fertilizers via surface broadcasting on dry soil is an incorrect practice because it leads to high volatilization losses and poor nutrient uptake. Under dryland conditions, fertilizers must be placed deep into the moist root zone. This ensures that nutrients remain chemically available to the plant even as the topsoil layer dries out completely.

24. (C) Thornthwaite's Moisture Index
Thornthwaite's moisture index is a comprehensive aridity index that incorporates both water surplus and water deficit relative to the overall water need. By calculating these variables against potential evapotranspiration, this index defines the climatic boundaries of a region. This approach offers a highly precise representation of moisture adequacy for agricultural planning in dryland zones.

25. (D) I and III
Agricultural drought occurs when soil moisture reserves fall below the critical level required to sustain normal crop development. The moisture availability index is a valuable tool used to assess this risk by comparing rainfall probabilities with evapotranspiration demand. Conversely, falling groundwater tables and drying reservoirs are characteristic of hydrological drought, not meteorological drought.

26. (A) Substituting long-duration crops with short-duration, drought-escaping crops
When the onset of the monsoon is significantly delayed, traditional long-duration crops cannot complete their growth cycle within the shortened rainy season. The most appropriate contingency strategy involves substituting these varieties with short-duration, drought-escaping crops. These adaptive crops can mature quickly on the remaining moisture, reducing the risk of total yield failure.

27. (B) It is a growth retardant that restricts shoot growth and increases root-to-shoot ratio
Cycocel, chemically known as chlormequat chloride, is a synthetic plant growth retardant utilized in dryland agronomy. It inhibits gibberellin biosynthesis, which restricts excessive vegetative shoot elongation and produces sturdier stems. By reducing shoot biomass, Cycocel

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optimizes the root-to-shoot ratio, allowing the crop to conserve critical water resources and withstand prolonged periods of moisture stress.

28. (B) The probability of a weather state occurring given the state of the preceding period
In rainfall analysis, the Markov chain model utilizes conditional probability to define the likelihood of a specific weather event occurring based on the state of the preceding period. This statistical approach calculates the probability of a wet or dry week following a wet or dry week, providing valuable forecasting data for scheduling agricultural operations.

29. (A) Upregulating superoxide dismutase and catalase enzymes
Drought stress induces the overproduction of reactive oxygen species within plant cells, leading to oxidative damage of lipids, proteins, and DNA. To counteract this threat, plants activate an enzymatic defense system. Upregulating key antioxidant enzymes, such as superoxide dismutase and catalase, allows the plant to efficiently scavenge these toxic molecules and protect vital cellular components.

30. (C) Hexadecanol – Film-forming type
Antitranspirants are chemicals applied to foliage to reduce water loss, categorized by their mode of action. Hexadecanol is a long-chain fatty alcohol that functions as a film-forming antitranspirant by creating a physical barrier to water vapor. In contrast, kaolin is a reflectant, while phenyl mercuric acetate and low concentrations of atrazine act as stomatal closing agents.

31. (D) Agri-silviculture
Agri-silviculture is an alternate land use system designed for dryland environments, deliberately integrating woody perennials with annual arable crops on the same land unit. This system optimizes resource use by exploiting different soil depths and canopy layers. It provides farmers with diverse income sources, such as food, fuel, and fodder, while enhancing overall soil conservation.

32. (C) To safely dispose of excess runoff while conserving in-situ soil moisture
The Broad Bed and Furrow system is a highly effective in-situ soil and water conservation practice for deep black clay soils. Vertisols are prone to waterlogging during heavy rainfall and cracking during dry periods. The BBF system safely drains excess surface runoff through the furrows while simultaneously conserving moisture and improving aeration within the broad crop beds.

33. (B) I and III
The length of growing period is a crucial agro-ecological concept that integrates precipitation, potential evapotranspiration, and stored soil moisture. It is incorrect to state that calculations ignore stored soil water, as profile moisture directly extends the growing season. Furthermore, since soil types and rainfall patterns vary, the growing period is never identical across the same latitude.

34. (D) Fragmentation of landholdings and lack of capital for machinery
The widespread adoption of mechanized precision agronomy in dryland farming is heavily restricted by socio-economic constraints. Most dryland farmers manage small, highly fragmented landholdings, which makes the deployment of large-scale machinery economically unviable. Additionally, a lack of institutional credit and limited capital resources prevent these resource-poor farmers from investing in advanced agricultural technologies.

35. (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
Dry seeding is an important adaptation strategy practiced in dryland areas prior to the onset of the monsoon rains. This technique involves sowing seeds in dry soil, allowing them to germinate immediately upon receiving the first monsoon showers. This ensures that the crop utilizes the early season rainfall efficiently, maximizing the overall duration of the active growing season.

36. (C) Premature leaf senescence and floral abortion
The drought syndrome in agricultural crops refers to a suite of physiological and morphological changes induced by severe water deficits. A primary symptom of this stress is premature leaf senescence, which reduces the active photosynthetic area. Additionally, floral abortion and impaired fertilization commonly occur, leading to a substantial decrease in the final grain yield.

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these rainfall fluctuations is critical for designing robust contingency plans and water harvesting structures.

56. (C) Tie-ridging blocks furrows with earth ties to prevent lateral runoff
Tie-ridging is a modified ridge-and-furrow system designed to maximize in-situ soil moisture conservation. This technique involves constructing small, transverse earthen barriers or "ties" at regular intervals across the furrows. These ties block the lateral movement of water, creating a series of small basins that retain surface runoff and force it to infiltrate directly into the crop root zone.

57. (D) Targeted water application during critical stages to prevent crop failure
Life-saving or supplemental irrigation refers to the strategic application of a limited quantity of water during critical growth stages of rainfed crops. This intervention is designed to alleviate severe moisture stress and prevent total crop failure during prolonged dry spells. It optimizes water use efficiency by targeting only the most drought-sensitive developmental phases of the crop.

58. (A) Jodhpur
The Central Arid Zone Research Institute is a premier research organization located in Jodhpur, Rajasthan. Established in 1959, this institute conducts multi-disciplinary research on desertification control, wind erosion mitigation, and sustainable land management in arid regions. It develops technologies for sand dune stabilization, rainwater harvesting, and alternative farming systems suitable for extreme desert climates.

59. (B) Phenological plasticity and short duration
When formulating a contingency crop plan for highly erratic rainfall situations, agronomic priority is given to crops with high phenological plasticity and short growth durations. These characteristics allow the crop to complete its lifecycle within a variable and shortened moisture window. Short-duration varieties reduce risk by escaping late-season droughts that would destroy late-maturing crops.

60. (B) P-1, Q-4, R-2, S-3
Plants utilize distinct adaptation mechanisms to survive moisture stress. Ephemerals exhibit drought escape by rapidly completing their life cycle. Deep taproot development is a key drought avoidance trait that accesses sub-surface water. Cellular accumulation of proline facilitates osmotic adjustment to maintain turgor pressure. A glaucous wax coating on leaves increases reflectance, reducing the overall solar heat load.

61. (C) Anthesis and active grain filling
Anthesis and active grain filling represent the most moisture-sensitive growth stages across almost all agricultural crops. Occurring during the reproductive phase, drought stress at this time severely impairs fertilization, reduces pollen viability, and disrupts assimilate translocation. Consequently, even short dry spells during these stages cause irreversible yield losses and decrease the final harvest index.

62. (C) Shallow inter-cultivation creating a loose topsoil layer to break capillary continuity
Dust mulch is an ancient dry farming technique created by performing shallow inter-cultivation or hoeing on the soil surface. This practice pulverizes the topmost soil layer, creating a loose, dry barrier. This loose layer disrupts the continuity of capillary pores, blocking the upward capillary rise of water from deeper soil horizons and significantly reducing evaporative water loss.

63. (D) Defined row-proportions utilizing additive or replacement series
In erratic rainfall environments, structuring intercropping systems with defined row-proportions optimizes the complementary use of resources. Combining deep-rooted and shallow-rooted companion crops allows them to extract moisture from different soil horizons simultaneously. This spatial arrangement reduces below-ground competition for water and nutrients, stabilizing total crop yields compared to random broadcasting or sole cropping.

64. (C) II only
Top-dressing solid nitrogenous fertilizers during severe dry spells is an incorrect agronomic practice under dryland conditions. Without adequate soil moisture, the applied fertilizer remains undissolved on the surface, leading to severe volatilization losses and chemical crop injury. Conversely, deep placement of basal fertilizer and splitting nitrogen applications

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46. (C) Cultivation dependent on rainfall without supplemental irrigation
Rainfed farming refers to crop production in agricultural areas where soil moisture depends entirely on natural rainfall, without any supplemental irrigation from surface or groundwater sources. This system typically occurs in regions receiving more than 1150 millimeters of annual precipitation, where the crop growth cycle is relatively long and water availability is generally less limiting.

47. (D) Number of wet weeks divided by total weeks in the dataset
The initial probability of a wet week in rainfall analysis is calculated by dividing the number of wet weeks by the total number of weeks in the historical dataset. This simple mathematical relationship provides a baseline probability of receiving rain during any given week, helping researchers understand the basic distribution and reliability of regional precipitation.

48. (C) Cell expansion and division due to turgor loss
During severe agricultural drought, the loss of cellular turgor pressure is the primary physiological bottleneck that impairs plant growth. Since cell expansion and division depend heavily on turgor pressure, any reduction in water potential immediately halts vegetative elongation. This early disruption triggers a cascade of developmental failures, reducing the plant's overall yield potential.

49. (B) It creates small barriers that intercept runoff to increase infiltration
Contour farming involves performing all agricultural operations, such as plowing, planting, and weeding, across the slope rather than up and down. This spatial arrangement creates small, horizontal ridges that act as physical barriers to intercept surface runoff. By slowing down water movement, contour farming increases the time available for infiltration and reduces soil erosion.

50. (C) (A) is true but (R) is false
Foliar application of reflectant-type antitranspirants, such as kaolin clay, increases the albedo of the crop canopy and lowers leaf temperature. By reflecting a significant portion of incoming solar radiation, these compounds reduce the heat load on the foliage. However, reflectants do not physically block stomatal pores; that mechanism is characteristic of film-forming or chemical closing agents.

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51. (A) Cessation of rainfall well before crop physiological maturity
An early withdrawal of the monsoon is defined as the premature cessation of seasonal rainfall well before the cultivated crops reach physiological maturity. This climatic aberration subjects the crops to severe moisture stress during the critical grain-filling and ripening stages. Consequently, it causes drastic yield reductions and compromises the quality of the harvested grain.

52. (C) Infiltration rate and topography
The effectiveness of compartmental bunding in conserving in-situ moisture is primarily determined by soil infiltration rate and topography. This practice involves dividing fields into small, rectangular basins using earthen bunds. It works best in heavy soils with slow infiltration rates and gentle slopes, where the bunds hold runoff water long enough to force uniform infiltration.

53. (A) Drought avoidance
A deeply penetrating root system is a classic morphological adaptation representing drought avoidance in crops. By extending roots into deeper soil horizons, the plant can access and extract moisture reserves that are unavailable to shallow-rooted species. This allows the crop to maintain favorable internal water status and continue transpiration even when the topsoil is completely dry.

54. (D) I, III and V
Soil and water conservation measures form the foundational tier of integrated watershed management. Within this framework, a milli-watershed is categorized as covering an area of one thousand to ten thousand hectares. Alternate land use systems, such as agri-silviculture, are highly suitable for marginal lands, whereas check dams primarily serve to reduce runoff velocity and promote shallow local recharge.

55. (B) High variation in annual rainfall distribution
The semi-arid drylands of India are primarily characterized by high inter-annual and intra-seasonal variation in rainfall distribution. This high variability makes crop production highly risky and unpredictable, as dry spells can occur at any stage of plant development. Understanding

74. (A) P-2, Q-1, R-4, S-3
Watershed management utilizes specific terminology and structures to optimize soil and water resources. The catchment area represents the entire geographical zone draining into a common outlet. A mini-watershed is categorized as covering ten to one hundred hectares. Practices like contour bunding and broad bed and furrows facilitate in-situ moisture conservation, while check dams serve as gully control structures.

75. (B) Severe wilting, impaired cell division, and disrupted development
The drought syndrome in agricultural crops refers to the collective physiological and biochemical symptoms induced by severe water deficits. This condition is characterized by severe wilting due to turgor loss, which directly impairs cell division and elongation. It disrupts normal vegetative and reproductive development, leading to premature leaf senescence, floral abortion, and substantial yield declines.

76. (B) Clear plastic mulches are used to cool the soil surface in peak summer
Clear plastic mulches do not cool the soil surface; instead, they transmit solar radiation and trap heat, which significantly increases soil temperature. This warming effect is utilized for soil solarization to control weeds and pathogens. In contrast, organic and dust mulches successfully moderate soil temperatures, reduce evaporation, and improve moisture conservation in dryland cropping systems.

77. (A) Water shortage affects economic goods supply and societal well-being
Socio-economic drought occurs when a severe physical water shortage begins to directly impact the supply and demand of economic goods and services. This type of drought integrates meteorological, agricultural, and hydrological deficits with human and economic activities. It manifests when water scarcity restricts industrial production, drinking water supplies, and food distribution, thereby reducing overall societal well-being.

78. (C) ICAR-CRIDA
The Central Research Institute for Dryland Agriculture was established in 1985 in Hyderabad by the Indian Council of Agricultural Research. It serves as the nodal agency for conducting and coordinating research in rainfed farming systems across India. CRIDA develops sustainable resource management technologies, crop contingency plans, and climate-resilient farming systems to support resource-poor dryland farmers.

79. (D) Applying artificial lining materials to prevent seepage losses
Constructing rainwater harvesting farm ponds in highly permeable sandy soils requires the application of artificial lining materials to prevent rapid seepage. Sandy soils have low clay content and high macro-porosity, which facilitates high water infiltration rates. Installing durable linings, such as high-density polyethylene sheets, ensures that the harvested water remains stored for agricultural use.

80. (C) I and II
Ratooning is a highly effective mid-season corrective practice for crops like sorghum when early drought stunts the main shoot but late rains occur. Additionally, a foliar spray of two percent urea helps rapidly revive crop foliage once moisture is restored. Conversely, crop thinning decreases inter-plant competition, and critical reproductive stages are the highest priority for irrigation.

81. (B) Emphasizing moisture conservation and drought-tolerant cropping systems
Dryland farming regions, receiving annual rainfall between 750 and 1150 millimeters, are characterized by moderate moisture stress and a high risk of seasonal dry spells. Consequently, crop production in these zones prioritizes robust in-situ moisture conservation practices and the selection of drought-tolerant cropping systems. These practices ensure stable yields and optimize rain use efficiency throughout the year.

82. (D) Short-duration pearl millet varieties
Short-duration pearl millet varieties are classic examples of plants utilizing drought escape as their primary survival mechanism. These crops have been bred to complete their entire developmental cycle, from germination to seed maturity, within a very short timeframe. By maturing rapidly, they complete their life cycle before the soil profile moisture is completely depleted by post-monsoon dryness.

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based on rainfall are highly recommended practices.

65. (B) Percolation tanks impound runoff specifically for localized groundwater recharge
Percolation tanks differ fundamentally from farm ponds in their design and primary hydrological objective within a watershed. While farm ponds are lined structures intended to store surface runoff for direct supplemental irrigation, percolation tanks are unlined basins built in highly permeable areas. They impound runoff to facilitate maximum downward water movement, recharging the local groundwater aquifer.

66. (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
Stomatal closing antitranspirants reduce both transpiration and photosynthesis because they induce physical closure of the stomatal apertures. This restriction limits the outward diffusion of water vapor, conserving plant moisture. However, because the stomata are closed, the inward diffusion of carbon dioxide is also blocked, which directly reduces the rate of photosynthetic carbon assimilation in the leaves.

67. (A) Troll's System
Troll's climatic classification system defines regional aridity based on the number of humid months, where precipitation exceeds potential evapotranspiration. This system categorizes climates into arid, semi-arid, and sub-humid zones based on the duration of agricultural water security. It is widely utilized in tropical and semi-arid regions to assess the feasibility of different cropping systems.

68. (C) It calculates the sequential dependency of wet and dry periods using probabilities
The Markov chain model provides a significant statistical advantage in dryland agricultural planning by evaluating the sequential dependency of weather states. Unlike simple arithmetic averages, this probability model calculates the likelihood of wet or dry periods based on the status of the preceding week. This analysis enables agronomists to assess dry spell frequencies and optimize sowing windows.

69. (A) Moderating soil temperature and enhancing moisture retention
Crop residue management is a cornerstone of dryland conservation agriculture, focused on maintaining a protective organic cover over the soil surface. This layer reduces evaporative moisture loss by shielding the soil from direct solar radiation. Additionally, crop residues moderate extreme soil temperatures, enhance biological activity, and protect the soil surface from the physical impact of raindrops.

70. (D) Formation of a dense surface layer upon drying that inhibits seedling emergence
Soil crusting is a critical biophysical constraint occurring when rain drops impact bare, structurally unstable soils, dispersing clay and silt particles. These fine particles clog surface pores and, upon rapid drying, cement into a hard surface layer. This dense crust acts as a strong physical barrier that restricts seedling emergence, decreases aeration, and severely reduces water infiltration.

71. (B) Strategic crop thinning by removing alternate rows or weaker plants
Mid-season crop thinning is a tactical intervention designed to salvage remaining soil moisture during prolonged dry spells. By systematically removing alternate rows or weaker plants, farmers reduce the total leaf area index and transpirational water demand. This reduction in plant population conserves the limited available soil moisture, allowing the remaining crop plants to survive and mature successfully.

72. (C) II and IV
Cycocel is an effective growth retardant that restricts vegetative shoot elongation, helping crops conserve energy and water under stress. Additionally, silicone-based oils function as film-forming antitranspirants by creating a physical barrier over the leaves. Conversely, phenyl mercuric acetate is a stomatal closing agent, and reflectants decrease leaf temperature by lowering the absorbed heat load.

73. (D) Delivering targeted liquid nutrients to the root zone with life-saving irrigation
Aqua-fertigation is a highly efficient precision agronomy technique developed for dryland conditions. It involves delivering highly targeted liquid nutrients directly into the active crop root zone along with a minimal, localized application of water. This practice maximizes fertilizer use efficiency during dry spells, ensuring that crops absorb essential nutrients and moisture simultaneously despite overall soil dryness.

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37. (A) Clear polyethylene mulch
Clear polyethylene mulch is a synthetic material that uniquely modifies the soil micro-climate in agricultural fields. Unlike organic residues, transparent plastic film allows solar radiation to pass through and heat the soil beneath while trapping moisture. This process, known as soil solarization, significantly increases soil temperatures during the day while preventing evaporative water loss.

38. (D) Deep intra-row crop thinning
During a prolonged dry spell in the vegetative phase, deep intra-row crop thinning is highly recommended as a mid-season corrective measure. By removing weaker plants or alternate rows, farmers reduce the overall plant population. This practice decreases transpiration demand and conserves the remaining soil moisture, allowing the surviving plants to complete their development and produce yields.

39. (B) International Crops Research Institute for the Semi-Arid Tropics
The International Crops Research Institute for the Semi-Arid Tropics was established in 1972 at Patancheru, near Hyderabad. This international organization conducts agricultural research to improve crop productivity and resource management in the semi-arid tropics. It focuses on breeding resilient varieties of mandate crops, including chickpea, pigeonpea, pearl millet, sorghum, and groundnut, to enhance food security.

40. (C) II, III, IV, I
Efficient rainwater management follows a logical sequence starting with in-situ moisture conservation to maximize rainfall absorption directly in the field. Excess water is then channeled through catchment runoff generation into farm pond storage structures. Finally, this harvested water is utilized for high-priority supplemental irrigation during critical crop growth stages to prevent complete yield failure.

41. (D) Assured rainfall at 75% probability and reference evapotranspiration
Hargreaves' Moisture Availability Index is a reliable climatic indicator calculated as the ratio of assured rainfall at a seventy-five percent probability level to the reference evapotranspiration. This index measures the adequacy of natural precipitation in meeting crop water demands. It helps agronomists classify regional aridity and determine optimal cropping patterns for rainfed farming systems.

42. (A) Minimizing soil disturbance to retain residues and preserve structure
Reduced tillage is a fundamental component of conservation agriculture that minimizes mechanical soil disturbance. By leaving crop residues on the soil surface, this practice protects the soil from erosion and preserves its natural structure. Consequently, it enhances water infiltration, reduces evaporative losses, and maintains higher organic matter content compared to conventional intensive tillage systems.

43. (B) Drought avoidance
Leaf rolling or folding is a classic physiological adaptation mechanism representing drought avoidance in plants under severe moisture stress. When turgor pressure drops during intense mid-day heat, specialized bulliform cells lose water, causing the leaf blade to roll inward. This physical change reduces the exposed surface area, minimizes transpiration, and lowers leaf temperature.

44. (B) I and III
Aqua-fertigation represents a precise nutrient delivery system where liquid fertilizers are injected directly into the moist root zone along with minimal water. Additionally, split application of nitrogenous fertilizers is highly effective under dryland conditions if timed with active rainfall events. Conversely, surface broadcasting during dry spells leads to severe nutrient losses, making deep placement necessary.

45. (A) P-2, Q-4, R-1, S-3
Integrated watershed management components are designed to achieve specific functional outcomes. Contour farming intercepts surface runoff across slopes, enhancing in-situ water infiltration. Percolation tanks are constructed to promote deep groundwater recharge. Silvi-pasture systems integrate forestry with pasture to provide fodder and stabilize degraded lands. Dry seeding enables timely crop establishment using early monsoon rains.

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83. (C) (A) is true but (R) is false
Intercropping is a highly recommended practice in rainfed agriculture because it provides biological insurance and stabilizes crop yields. However, the system does not succeed by utilizing companion crops with identical root architectures and maturity durations. Instead, it relies on species with diverse, complementary growth habits to minimize competition and maximize the utilization of soil resources.

84. (C) Basal deep placement using seed drills
Basal deep placement of fertilizers using specialized seed drills ensures that plant nutrients are placed directly into the sub-surface soil horizons. This depth protects the fertilizer from rapid drying on the surface, keeping nutrients chemically available for root uptake. This placement technique promotes deeper root proliferation, enhancing the crop's resilience to subsequent dry spells.

85. (A) Duration when soil moisture and temperature are adequate for active crop growth
The length of growing period represents the continuous duration during the year when both soil moisture and ambient temperature are fully adequate to support active crop growth. This period begins when natural precipitation exceeds fifty percent of the potential evapotranspiration and extends to include the time required to deplete stored soil moisture reserves after rainfall ceases.

86. (D) Agri-silvi-pasture and silvi-pasture systems
Agri-silvi-pasture and silvi-pasture systems are integrated watershed management interventions specifically designed to stabilize highly degraded, uncultivable upper slopes. These systems combine woody perennial trees with nutritious forage grasses and annual crops on marginal lands. This configuration prevents soil erosion, enhances water infiltration, and provides sustainable, year-round sources of timber, fuel, and livestock fodder.

87. (B) Mean temperature and precipitation
The Koppen climatic classification system defines the boundaries of arid and semi-arid regions by integrating mean monthly temperature and annual precipitation. This quantitative approach evaluates the relationship between temperature, which drives evaporation, and precipitation, which supplies moisture. By analyzing these two key atmospheric variables, the system classifies global climates and maps corresponding vegetation distributions.

88. (C) II only
Agricultural drought occurs when soil moisture reserves are insufficient to meet the transpirational demands of crops, leading to severe water stress and yield loss. It is incorrect to state that agricultural drought occurs exclusively when surface reservoirs dry up, as reservoir depletion is a defining characteristic of hydrological drought, which affects broader water storage systems.

89. (D) Cell elongation and excessive vegetative shoot extension
Cycocel acts as an effective plant growth retardant by specifically inhibiting the biochemical synthesis of gibberellins within plant tissues. This inhibition restricts cell division and elongation, thereby preventing excessive vegetative shoot extension and producing more compact, sturdy crop plants. By limiting shoot development, it reduces transpirational water demand and improves the crop's root-to-shoot ratio.

90. (A) P-2, Q-4, R-1, S-3
Agronomists deploy specific mid-season correction strategies to mitigate different aberrant weather situations. Crop thinning is practiced during prolonged mid-season dry spells to reduce moisture demand. Life-saving irrigation targets critical crop growth stages experiencing severe stress. Delayed monsoons require sowing short-duration alternative crops, while extreme early withdrawal of the monsoon often necessitates harvesting the crop early for fodder.

91. (B) Utilizing rainfall probability analyses and LGP mapping
Determining the optimal sowing window in dryland agriculture relies heavily on analyzing historical rainfall probability and mapping the length of growing period. These scientific tools calculate the reliability of early season rainfall events and estimate the duration of moisture availability in the soil. This analysis minimizes the risk of seedling mortality and aligns crop growth with moisture security.

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92. (B) Potassium regulates turgor pressure and stomatal opening and closing
Potassium fertilization is highly critical during drought stress because this nutrient plays a fundamental physiological role in regulating turgor pressure and stomatal activity. Adequate potassium levels enable the plant to maintain cellular hydration and control the opening and closing of stomata efficiently. This regulation minimizes transpirational water loss while allowing necessary carbon dioxide assimilation under stress.

93. (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
Minimum or zero tillage is highly recommended under conservation agronomy in dryland farming systems. This practice minimizes physical soil disturbance, which helps preserve crop residues on the surface. This organic residue layer acts as a protective mulch, significantly reducing evaporative water loss from the soil while moderating extreme soil temperatures and protecting soil structure.

94. (D) It encompasses a vast area exceeding 50,000 hectares
According to the standardized hierarchical classification of watersheds in India, a macro-watershed is defined as a vast hydrological unit encompassing an area that exceeds fifty thousand hectares. This extensive scale represents the highest level in watershed planning, integrating several sub-watersheds and micro-units to facilitate comprehensive regional planning, river basin management, and long-term environmental conservation.

95. (D) II and III
Supplemental irrigation utilizing harvested rainwater is highly effective when applied during moisture-sensitive critical growth stages, preventing severe yield losses. Furthermore, catchment area treatment is a vital watershed intervention that reduces the silt load entering storage structures, extending their lifespan. Conversely, open farm ponds suffer from evaporation, and vertisols naturally limit deep percolation.

96. (C) Pre-sowing hydration-dehydration cycles enabling seeds to withstand drought
Seed hardening is a pre-sowing physiological treatment that involves subjecting seeds to controlled hydration-dehydration cycles. Soaking seeds in water initiates early physiological processes without allowing radicle emergence, while subsequent drying halts development. This priming process strengthens cellular membranes and enhances enzymatic activity, enabling the emerging seedlings to withstand subsequent drought and heat stress.

97. (B) It acts as an earthen block in the furrow to prevent lateral runoff
In a tie-ridging system, a tie is a small earthen barrier constructed transversely across the furrows at regular intervals. The primary physical function of these ties is to act as blocks that prevent the lateral flow of surface runoff along the furrows. This creates a series of small basins that retain rainwater, forcing localized in-situ infiltration.

98. (D) Limited access to credit and high cost of critical inputs
Dryland agricultural development faces multiple challenges, but limited access to institutional credit and the high cost of critical inputs are categorized strictly as socio-economic constraints. Unlike biophysical factors, such as soil crusting, or climatic constraints, like erratic rainfall patterns, these economic barriers restrict resource-poor farmers from purchasing quality seeds, modern fertilizers, and water harvesting equipment.

99. (A) They are highly cost-effective and universally recommended for low-value cereals
Antitranspirants are not universally recommended or highly cost-effective for low-value cereal crops because the cost of chemical application often outweighs the marginal yield benefits. Instead, their use is most practically and economically justified in high-value horticulture, orchards, or micro-nurseries. Additionally, stomatal closing types can significantly and irreversibly reduce net photosynthesis by restricting carbon dioxide uptake.

100. (C) P-3, Q-4, R-2, S-1
Different agricultural and climatic indices utilize specific variables to evaluate moisture availability. Thornthwaite's index integrates water surplus, deficit, and overall water need. Troll's system utilizes the number of humid and dry months to define climatic zones. Length of growing period calculations determine where

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precipitation and evapotranspiration curves intersect, while Markov chain analysis calculates initial and conditional probabilities.

101. (A) Implementing alternate land use systems like silvi-pasture and horticulture
The Integrated Watershed Management Programme emphasizes alternate land use systems, such as silvi-pasture and dryland horticulture, to generate sustainable alternative livelihoods. These systems utilize marginal, uncultivable lands within the watershed to provide stable sources of income, fuel, and livestock fodder. This approach minimizes pressure on common property resources while enhancing soil and water conservation.

102. (D) Substituting a proportion of the main crop with the intercrop, keeping total density constant
In a replacement series intercropping system, a specific proportion of the primary main crop is substituted with a companion intercrop while keeping the total plant population density constant. This mathematical arrangement differs from additive series, where the intercrop is added to the full population of the main crop. It helps optimize resource use and reduces inter-species competition.

103. (B) Proline acts as a compatible osmolyte, lowering osmotic potential to maintain turgor
Proline accumulation is a vital physiological adaptation that enhances drought tolerance by acting as a compatible cellular osmolyte. When plants experience moisture stress, accumulating proline lowers the osmotic potential within the cells. This adjustment facilitates water uptake from dry soils, allowing the plant to maintain cell turgor pressure, protect metabolic enzymes, and stabilize cellular membranes.

104. (C) Switching to short-duration, photo-insensitive crops that can mature within the shortened LGP
If the monsoon is exceptionally delayed beyond the normal sowing window, the most scientifically sound contingency strategy is to switch to short-duration, photo-insensitive crops. These adapted species can complete their growth cycle within the shortened length of growing period. This selection minimizes the risk of total crop failure by avoiding severe late-season moisture deficits.

105. (D) I, III and V
Controlling weeds eliminates unnecessary transpirational water loss, and establishing shelterbelts reduces wind velocity to decrease evaporative demand. Additionally, stubble mulching protects the soil surface from erosion while reducing evaporation. However, it is incorrect to state that organic mulches do not moderate soil temperatures, and clear plastic mulches are used to warm rather than cool the soil.

106. (B) III, I, II, IV
Contingency crop planning requires structured steps to manage seasonal weather aberrations. The process begins with pre-positioning short-duration seeds and inputs. Next, real-time weather data is assessed to identify specific deviations. Farmers then execute planned mid-season corrections or alternate crop sowings. Finally, crop recovery is monitored to adjust terminal harvest strategies.

107. (B) It creates miniature ridges and furrows across the slope to intercept and retain rainfall
Contour farming is a highly effective in-situ moisture conservation practice where agricultural operations are performed across the slope. This orientation creates miniature barriers, ridges, and furrows that physically intercept surface runoff. By slowing down water movement, it increases the opportunity time for water infiltration, thereby significantly enhancing soil moisture storage.

108. (B) Potential Evapotranspiration (PET)
Severe dryland constraints are heavily exacerbated when a region experiences high potential evapotranspiration alongside low rainfall. This climatic parameter represents the atmospheric demand for moisture. High potential evapotranspiration rates accelerate water loss from both the soil surface and plant canopy, rapidly depleting available root-zone moisture and intensifying drought stress on crops.

109. (A) Both A and R are true and R is the correct explanation of A.
Deep tillage using subsoilers is highly recommended for specific dryland soils containing dense subsurface layers. Subsoiling physically breaks and shatters naturally occurring hardpans or compaction caused by heavy machinery traffic. This structural modification facilitates

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in-situ moisture, they establish the necessary ecological and physical conditions required for subsequent agricultural activities to succeed.

145. (A) Both A and R are true and R is the correct explanation of A.
The Moisture Availability Index is highly critical for determining optimal cropping patterns in dryland regions. This index integrates assured rainfall at specific probability levels with local potential evapotranspiration. By evaluating this ratio, it provides a realistic, statistically sound assessment of moisture adequacy throughout the crop season, guiding the selection of appropriate crop durations and planting dates.

146. (D) It inherently prevents the generation of all Reactive Oxygen Species (ROS) during stress
Osmotic adjustment is an essential drought-tolerance mechanism involving the active accumulation of compatible solutes like proline and sugars. This process maintains cell turgor and allows continuous water extraction from drying soils. While it supports vital metabolic functions during stress, osmotic adjustment does not inherently prevent the generation of all reactive oxygen species inside plant cells.

147. (A) An area encompassing 10,000 to 50,000 hectares
In Indian watershed management programs, hydrological units are systematically categorized based on their total geographical area. A sub-watershed is precisely defined as an area encompassing ten thousand to fifty thousand hectares. This standard classification helps planners design appropriate administrative frameworks, soil conservation structures, and land-use interventions suited to this specific scale.

148. (A) P-3, Q-1, R-2, S-4
Agronomic interventions in drylands address specific moisture constraints. Ratooning is used to salvage stunted crops by utilizing late rains for new growth. Dust mulching creates a loose soil layer that interrupts capillary channels, reducing evaporation. Seed hardening induces early physiological drought resilience in seedlings, while split application of nitrogen optimizes nutrient use efficiency under uncertain rainfall.

149. (C) III, I, II
Dryland climatic zones are classified based on annual rainfall and moisture availability. The sequence representing increasing moisture adequacy begins with dry farming, typical of arid regions receiving low rainfall. This is followed by dryland farming in semi-arid zones with moderate, erratic rainfall. Finally, rainfed farming occurs in sub-humid to humid areas characterized by high annual precipitation.

150. (D) The probability of receiving rainfall in a given week regardless of the preceding week's weather state
In rainfall probability analysis using the Markov chain model, the initial probability represents a fundamental baseline. It is defined as the statistical probability of a specific week receiving a threshold amount of rainfall, calculated independently without considering the wet or dry state of the preceding week. This parameter helps characterize overall moisture availability trends over time.

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151. (B) Basal cellular respiration and minimal cell membrane integrity maintenance
During prolonged and severe drought stress, plants experience a sequential shutdown of physiological processes. Cell expansion and transpirational water loss cease first, followed by a total decline in photosynthesis. The final processes to fail are basal cellular respiration and the maintenance of minimal cell membrane integrity. The collapse of these basic processes marks irreversible plant death.

152. (A) I, II and IV
Selecting crop varieties for dryland systems requires specific adaptive traits. Desirable characteristics include high phenological plasticity to adapt to varying growing periods, and deep, dense root systems to extract water from lower soil profiles. Additionally, early seedling vigor promotes rapid canopy closure, which minimizes evaporation. Long-duration or strict photoperiod-sensitive varieties are generally avoided.

153. (D) It minimizes soil inversion, keeping moisture within the profile and preserving protective residue cover
Conservation tillage manages dryland moisture constraints by minimizing soil inversion. Standard intensive tillage exposes deep soil

118. (D) Silvi-pasture systems establishing perennial hardy fodder trees and forage grasses
Severely degraded, shallow soils belonging to Land Capability Classes five to seven are highly vulnerable to erosion and completely unsuitable for annual crop cultivation. Establishing a silvi-pasture system with perennial, hardy fodder trees and forage grasses is the most appropriate land-use strategy. This system provides stable ground cover, prevents soil degradation, and yields valuable livestock fodder.

119. (A) Both A and R are true and R is the correct explanation of A.
Deep placement of basal fertilizers in dryland agriculture results in significantly higher nutrient use efficiency compared to surface broadcasting. This positioning physically prevents volatile losses of elements like nitrogen. Furthermore, it places nutrients directly into the deeper, consistently moist sub-surface soil zone where active crop roots are concentrated, ensuring continuous nutrient uptake despite dry topsoil conditions.

120. (C) Phenyl Mercuric Acetate (PMA) operates by physically reflecting incoming solar radiation
Antitranspirants are chemicals applied to foliage to reduce water loss. Mobileaf is a well-known commercial film-forming agent, and stomatal-closing types often reduce photosynthesis due to restricted carbon dioxide entry. However, Phenyl Mercuric Acetate functions specifically as a stomatal-closing chemical by affecting guard cells, rather than acting as a reflective material like kaolin.

121. (D) The ratio of assured rainfall at a specific probability level to potential evapotranspiration
The Moisture Availability Index is a key parameter in dryland climatology, calculated using Markov chain probability models. It is mathematically defined as the ratio of assured rainfall at a specific probability level, typically seventy-five percent, to the potential evapotranspiration. This index measures moisture adequacy, helping scientists determine optimal sowing dates and crop selections.

122. (A) Cellular turgor pressure, which is crucial for cell expansion and metabolic activity
Osmotic adjustment is a critical physiological mechanism where plants actively accumulate solutes during drought. This process lowers the cellular osmotic potential, facilitating continuous water uptake from dry soils. Consequently, it directly protects cellular turgor pressure, which is absolutely essential for cell division, leaf expansion, stomatal opening, and the maintenance of general metabolic activities.

123. (B) I, III and IV
Dry farming research in India began systematically in 1933 with five stations. The Central Rainfed Area Authority and the Central Research Institute for Dryland Agriculture coordinate dryland research, with the latter overseeing the coordinated network. The Jodhpur-based institute focuses on arid zones, while the international institute mandates semi-arid crops, excluding temperate cereals like wheat and barley.

124. (B) Using a diverse intercropping system with crops of different rooting depths and growth durations
In regions with erratic rainfall, monocropping carries a high risk of total crop failure. Utilizing a diverse intercropping system combining crops with different rooting depths and growth durations enhances farming resilience. This spatial and temporal diversification ensures that if one crop fails due to early or terminal drought, the other can still yield, stabilizing farm income.

125. (A) Contour bunds are field-intercepting barriers, while BBF is an in-field raised bed balancing moisture and drainage
Traditional contour bunds and Broad Bed and Furrow systems have distinct structural and functional designs. Contour bunds act as barrier structures constructed across slopes to intercept runoff and prevent erosion. Conversely, the Broad Bed and Furrow system is an in-field land management layout that conserves moisture in the beds while safely draining excess water through the furrows.

126. (A) P-4, Q-1, R-2, S-3
Lining farm ponds is essential to minimize seepage losses. Natural clay puddling is low-cost and moderately effective if the clay is rich in montmorillonite. High-density polyethylene liners are highly durable with extremely low seepage but carry high initial costs. Soil-cement mixtures require precise compaction and are crack-prone, while untreated sandy loam exhibits extremely high, inefficient seepage.

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deeper root penetration, allows crops to access moisture stored in lower soil horizons, and enhances overall drought resilience.

110. (C) Drought stress strictly enhances current photosynthate translocation, resulting in heavier grains
Drought stress during the grain filling stage impairs overall photosynthesis and accelerates leaf senescence, which shortens the duration of the filling phase. Under severe moisture deficits, current photosynthetic translocation is severely restricted rather than enhanced. Consequently, the plant is forced to rely heavily on remobilizing stored stem reserves, often resulting in shriveled, lighter grains.

111. (D) All India Coordinated Research Project for Dryland Agriculture (AICRPDA)
The All India Coordinated Research Project for Dryland Agriculture was established in 1970 to address the complex challenges of rainfed farming. This institutional body coordinates a vast network of research centers across diverse agro-climatic zones in India. It focuses on developing location-specific, sustainable technologies for moisture conservation, crop management, and contingency planning.

112. (C) Check dams are built across gullies to intercept channelized flow, while contour bunds span general slopes
Check dams and contour bunds serve distinct roles in soil and water conservation. Check dams are permanent or semi-permanent barriers constructed across gullies to intercept concentrated, channelized water runoff, trapping sediment and recharging groundwater. Conversely, contour bunds are earthen embankments constructed across general field slopes to intercept sheet erosion and retain in-situ moisture.

113. (B) The plant's capacity to maintain high tissue water potential during soil moisture deficits using deep roots or low transpiration
Drought avoidance is a specialized plant adaptation strategy where the organism maintains high tissue water potential despite low soil moisture. Plants achieve this by either maximizing water uptake through deep, extensive root systems or minimizing water loss through stomatal closure, thick cuticular waxes, and reduced leaf area, thereby delaying the onset of severe cellular dehydration.

114. (B) I and III
Aridity indices evaluate the degree of water deficiency in specific regions by comparing moisture supply to atmospheric demand. The Koppen climate classification system integrates temperature, precipitation, and natural vegetation patterns to define boundaries. In contrast, the Hargreaves classification incorporates potential evapotranspiration and rainfall ratios to determine regional water balance.

115. (A) To provide absorbable nitrogen bypassing dry roots, maintaining leaf greenness and aiding recovery after rain
Applying a foliar spray of two percent urea during prolonged mid-season dry spells is a vital agronomic measure. When dry soils restrict root nutrient absorption, foliar application delivers readily usable nitrogen directly through the leaves. This process maintains chlorophyll content, preserves photosynthetic machinery, and ensures the crop can recover quickly once rainfall resumes.

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116. (A) P-3, Q-1, R-2, S-4
Dryland agricultural productivity is constrained by multiple factors. Soil physical issues like surface crusting represent biophysical constraints. High inter-annual rainfall variability constitutes a major climatic constraint. Socio-economic limitations are exemplified by a lack of custom hiring centers for machinery, while technological gaps include the non-availability of localized, drought-resilient crop varieties.

117. (A) Controlling weeds mechanically or chemically during the critical crop-weed competition period
Weeds compete aggressively with crops for limited soil moisture and nutrients in dryland environments. Managing weeds mechanically or chemically during the critical crop-weed competition period is essential. This timely intervention eliminates unwanted transpirational water loss from the field, ensuring that conserved soil moisture is exclusively reserved for the growth and development of the main crop.

the leaf and atmosphere, effectively conserving plant moisture.

136. (B) Agri-silviculture
Agri-silviculture is an alternate land use system defined by the deliberate integration of agricultural crops and woody forest trees on the same land management unit. This spatial or temporal arrangement optimizes land productivity, enhances soil conservation, and provides farmers with multiple revenue streams from timber, fuelwood, and seasonal food crops under rainfed conditions.

137. (C) A is true but R is false.
Cultivating short-duration ephemeral crops is an excellent strategy for regions with an extremely short growing period. Ephemerals complete their lifecycle rapidly within a few weeks when moisture is available. However, they escape drought rather than tolerating it, and they do not possess extensive osmotic adjustment mechanisms to endure prolonged tissue dehydration over several months.

138. (C) Troll's climatic classification defines a semi-arid region strictly based on having 12 continuous humid months
Aridity indices are vital for defining climatic zones and guiding agricultural policies. Thornthwaite's moisture index accurately calculates water surplus and deficit against potential evapotranspiration. However, Troll's climatic classification defines semi-arid regions as having two to seven humid months where rainfall exceeds evapotranspiration, making the assertion of twelve continuous humid months completely incorrect.

139. (A) P-3, Q-4, R-2, S-1
Droughts are classified into distinct types based on their impact. Meteorological drought is indicated by negative deviations from mean precipitation. Agricultural drought is defined by soil moisture deficits causing crop stress. Hydrological drought involves the depletion of surface and groundwater reserves, while socio-economic drought occurs when water shortages disrupt the supply of economic goods.

140. (B) Dry seeding
Dry seeding is a precision agronomic technique where seeds are sown into completely dry soil prior to the onset of the monsoon. This practice allows seeds to germinate immediately upon receiving the first monsoon showers. It maximizes the utilization of early rains, extends the effective crop growing season, and ensures rapid, uniform seedling establishment in rainfed areas.

141. (A) It restricts the influx of atmospheric CO_2, causing a rapid decline in photosynthetic carbon assimilation
Under severe moisture stress, plants close their stomata to prevent excessive transpirational water loss. Although this conserves water, stomatal closure physically blocks the entry of atmospheric carbon dioxide into the leaf interior. This restriction directly limits the substrate available for the Calvin cycle, causing a rapid, severe decline in photosynthetic carbon assimilation and overall crop biomass.

142. (B) I and III
In-situ moisture conservation involves field-level practices. Compartmental bunding divides fields into small plots to retain rainwater uniformly. Broad Bed and Furrow systems are highly effective for managing moisture and drainage in vertisols. Conversely, contour farming is conducted perpendicular to slopes, and tie-ridging serves as an effective moisture conservation system.

143. (D) Organic mulches gradually decompose, improving soil organic carbon, aggregate stability, and overall soil health
Organic and stubble mulches provide distinct advantages over synthetic plastic mulches in sustainable dryland agriculture. Although synthetic plastics restrict evaporation, organic mulches slowly decompose over time. This decomposition process returns vital nutrients to the soil, increases soil organic carbon, enhances aggregate stability, promotes beneficial microbial activity, and improves long-term soil structure and moisture retention.

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144. (C) They are foundational, first-tier interventions required before establishing any advanced agronomic or horticultural activities
In micro-watershed development programs, soil and water conservation measures serve as foundational, first-tier interventions. These physical and vegetative structures must be implemented before introducing advanced agronomic, agroforestry, or horticultural practices. By stabilizing slopes and conserving

162. (A) Both A and R are true and R is the correct explanation of A.
Intercropping systems in drylands generally achieve a Land Equivalent Ratio greater than 1.0, indicating high biological efficiency. This advantage occurs because intercropping spatially and temporally separates resource demands between the component crops. By utilizing different rooting depths and canopy architectures, the crops utilize available soil moisture, nutrients, and solar radiation far more efficiently than sole crops.

163. (A) A 2% urea foliar spray is highly toxic and is strictly used as a chemical defoliant to end the crop cycle during a drought
Mid-season agronomic corrections are essential for managing weather aberrations. Practices like crop thinning reduce overall plant population and transpirational demand, while ratooning utilizes late rains for regrowth. Providing a life-saving irrigation from farm ponds during critical stages prevents yield collapse. However, foliar application of two percent urea is non-toxic and serves to nourish leaves, not defoliate crops.

164. (C) Thornthwaite System
The Thornthwaite system is a widely recognized climatic classification model. It categorizes global climatic zones based on the moisture index, which is derived from the precise balance between precipitation and potential evapotranspiration. This quantitative approach allows scientists to delineate arid, semi-arid, and sub-humid regions based on water surplus or deficit relative to atmospheric evaporative demand.

165. (A) The rapid onset of leaf senescence and severe limitation of current assimilate availability
Impaired grain filling during terminal drought stress is primarily driven by specific physiological changes. Severe moisture deficits restrict photosynthetic activity and accelerate leaf senescence, which drastically reduces the availability of current photosynthates. Consequently, the translocation of assimilates to developing grains is severely limited, forcing the crop to rely on finite stem reserves and resulting in shriveled seeds.

166. (A) P-4, Q-2, R-3, S-1
Conservation agriculture components provide multiple benefits in dryland systems. Reduced tillage preserves soil structure and macro-pores while saving energy. Crop residue retention moderates soil temperature and reduces evaporation. Contour farming slows surface runoff velocity across slopes to enhance infiltration, while dry seeding utilizes early pre-monsoon showers for prompt, uniform crop establishment.

167. (B) Dry farming ($<$ 750 mm) faces a higher crop failure frequency due to moisture deficits than dryland farming
Dry farming and dryland farming are distinguished by annual rainfall limits and associated risks. Dry farming is practiced in extremely dry regions receiving less than 750 mm of annual rainfall, where moisture deficits are severe and frequent. Consequently, dry farming systems face a significantly higher frequency of crop failure compared to dryland farming areas receiving 750 to 1150 mm.

168. (A) II, IV, I, III
A mesophytic crop experiencing sudden moisture stress undergoes a distinct sequence of physiological changes. The initial response is a reduction in cell expansion, which impairs leaf elongation. This is followed by stomatal closure and a subsequent decline in photosynthetic rates. Continued stress leads to a complete loss of turgor and permanent wilting, culminating in ROS generation and senescence.

169. (A) I, II and IV
Climatic and aridity indices are essential for agricultural planning. The Moisture Availability Index is calculated at a seventy-five percent rainfall probability level. Troll's classification delineates zones using the number of humid months, and the Koppen system utilizes letter codes for global climates. Thornthwaite's moisture index also incorporates potential evapotranspiration alongside rainfall data.

170. (C) A is true but R is false.
Cultivating deep-rooted crops like pigeonpea alongside shallow-rooted cereals is an excellent intercropping strategy for dryland systems. This combination optimizes spatial resource use, as deep-rooted crops extract moisture and nutrients from lower soil profiles. Because pigeonpea roots penetrate far below the shallow root zone of cereals, they minimize direct competition for water, rather than competing in the upper soil layers.

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layers, accelerating evaporative water loss. By reducing tillage operations, farmers keep soil moisture intact within the profile and preserve protective crop residue cover on the surface, which moderates soil temperature and shields the ground from erosive raindrop impacts.

154. (D) A is false but R is true.
Check dams are engineering structures constructed across gullies within a watershed. Their primary functions are to trap sediment, reduce runoff velocity, prevent gully erosion, and enhance localized groundwater aquifer recharge. They do not possess the capacity to modify regional microclimates to mimic humid tropical rainforests, but they effectively stabilize fragile landscapes.

155. (B) Foliar sprays can completely substitute the entire basal fertilizer requirement of a high-yielding crop
Foliar application of nutrients is an effective strategy in dryland agriculture because it bypasses dry topsoil where root uptake is restricted. Common solutions like urea and potassium chloride are rapidly absorbed through leaves during dry spells. However, foliar sprays cannot completely substitute the entire basal fertilizer requirement, as crops require large macro-nutrient volumes during early growth stages.

156. (B) Percolation tank
A percolation tank is a specialized water harvesting structure designed for groundwater recharge. Constructed across natural drainage lines on highly permeable soils, it impounds surface runoff and allows it to gradually percolate downward into the shallow aquifer. This structure is distinct from farm ponds, which are typically lined to prevent seepage and store water for irrigation.

157. (A) P-3, Q-1, R-4, S-2
Dryland agricultural research in India has evolved through key institutional milestones. The Dry Farming Research Stations established in 1933 conducted initial moisture conservation experiments. The Jodhpur institute focuses on desertification and arid zone management. The Hyderabad-based international institute researches semi-arid tropics globally, while the coordinated national project provides a pan-India network for localized research.

158. (C) Because dry spells at critical growth stages cause irreversible physiological damage and yield loss, despite adequate total seasonal rain
Analyzing dry spell frequency is more critical than total seasonal rainfall in dryland agriculture. A region may receive adequate cumulative rainfall, but if prolonged dry spells coincide with sensitive phenological stages like flowering or grain filling, crops suffer irreversible physiological damage. Consequently, the distribution and timing of rainfall dictate final yield outcomes more than seasonal totals.

159. (D) It forms a thin, semi-permeable polymeric barrier on leaves, increasing resistance to outward water vapor diffusion
Film-forming antitranspirants are chemicals applied to foliage to reduce water loss. Their specific mechanism of action involves creating a thin, physical, semi-permeable polymeric barrier over the leaf surface. This layer increases resistance to outward water vapor diffusion, thereby lowering transpiration rates. Crucially, these materials allow some carbon dioxide diffusion to maintain minimal photosynthetic activity during drought.

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160. (B) II, III and IV
The Length of Growing Period is a critical climatic indicator. It represents the period when precipitation exceeds half of potential evapotranspiration, plus the time soil moisture reserves are utilized. In arid regions, this period is extremely short, severely limiting crop options. Accurate models depend on precise historical climatic data and soil moisture holding capacity.

161. (B) Ensuring equitable resource sharing, generating alternate livelihoods, and fostering active community-led decision making
Modern watershed management programs integrate socio-economic development with physical soil and water conservation. The fundamental objective is to ensure equitable resource sharing among stakeholders, generate sustainable alternate livelihoods, and foster active, community-led decision-making processes. This holistic approach ensures long-term environmental sustainability and improves the overall quality of life for rural households in rainfed regions.

180. (A) Both A and R are true and R is the correct explanation of A.
Dryland precision agronomy strongly emphasizes strict adherence to optimal sowing windows. Sowing crops within these narrow, scientifically determined windows aligns sensitive growth stages, such as flowering and grain filling, with the period of highest historical rainfall probability and maximum moisture availability. This critical alignment minimizes the risk of terminal drought and optimizes crop yield.

181. (A) Surface broadcasting of urea on completely dry, hot soil is universally recommended as the most efficient application method
Efficient fertilizer application is critical in dryland farming to maximize nutrient use. Deep placement positions fertilizers in moist subsoil zones, while split applications help manage economic risks under erratic rainfall. However, broadcasting urea on completely dry, hot surface soil is highly inefficient. This practice results in severe ammonia volatilization losses and must be avoided.

182. (D) Inadequate precipitation leading to critical deficiencies in surface and sub-surface water resources like streams and reservoirs
Hydrological drought is defined by its impact on water storage and supply systems. It occurs when a prolonged period of inadequate precipitation leads to critical deficiencies in surface and subsurface water resources, such as streams, rivers, lakes, and reservoirs. This type of drought is measured by hydrological parameters rather than immediate soil moisture deficits.

183. (B) It supplies potassium to leaves, helping maintain turgor pressure and regulate stomatal behavior
Applying a foliar spray of potassium chloride during dry spells provides significant physiological benefits to rainfed crops. This intervention delivers potassium directly to the leaves, which is crucial for maintaining cellular turgor pressure. Furthermore, potassium plays a central role in regulating stomatal opening and closing, optimizing water use efficiency, and enhancing overall drought tolerance.

184. (A) P-2, Q-1, R-4, S-3
Agricultural research institutions in India have been established systematically over time. The Dry Farming Research Stations were initiated in 1933 to study moisture conservation. The Central Arid Zone Research Institute was established in 1959. The All India Coordinated Research Project for Dryland Agriculture started in 1970, followed by the International Crops Research Institute in 1972.

185. (A) II, III, I, IV
Drought management follows a hierarchical structure ranging from long-term planning to immediate salvage. The process begins with implementing long-term watershed and soil conservation structures. Before the season, farmers select drought-tolerant crops. During dry spells, they execute mid-season corrections like thinning. If these fail and crop failure is imminent, they harvest the crop prematurely for fodder.

186. (A) Fragmented landholdings and extreme resource poverty, limiting farmer investment and risk-taking
Dryland agriculture is constrained by distinct socio-economic challenges that limit overall productivity. Fragmented, small landholdings and extreme resource poverty are primary constraints. These factors limit farmers' capacity to invest in critical inputs, modern machinery, or water harvesting structures. Furthermore, high financial risk associated with erratic rainfall discourages adoption of advanced, capital-intensive agronomic technologies.

187. (B) I, III and IV
Seed hardening involves controlled hydration-dehydration cycles to induce physiological resilience, enabling faster, more vigorous germination under moisture stress. Dry seeding is practiced in dry soil to capitalize on early pre-monsoon showers for rapid establishment. However, dry seeding does not involve submerging seeds in water for an extensive period before sowing.

188. (B) Silvi-pasture
Silvi-pasture is a highly efficient alternate land use system designed for marginal watershed lands. It involves the deliberate, integrated cultivation of perennial, woody fodder trees alongside nutritious forage grasses on the same land unit. This system provides stable ground cover, prevents soil erosion, restores soil organic matter, and ensures a sustainable supply of livestock fodder.

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171. (B) Soil crusting
Soil crusting is a critical biophysical constraint in many semi-arid alfisols. It occurs when raindrop impact disperses soil aggregates, and subsequent rapid drying forms a hard, impermeable surface crust. This physical barrier significantly impedes seedling emergence, reduces infiltration rates, increases surface runoff, and ultimately leads to poor crop establishment and uneven plant stands in rainfed fields.

172. (B) Cycocel acts as a powerful defoliant, instantly stripping the plant of all functional leaves
Cycocel is a widely used plant growth retardant that improves drought tolerance by inhibiting gibberellin synthesis. This action reduces excessive vegetative shoot elongation and improves the root-to-shoot ratio, which helps conserve soil moisture by decreasing transpirational leaf surface area. However, Cycocel does not act as a defoliant to strip the plant of leaves, as its role is strictly regulative rather than destructive.

173. (A) An area typically ranging from 10 to 100 hectares
Under standard Indian watershed classifications, hydrological units are categorized by geographical size to optimize planning and implementation. A mini-watershed represents a highly localized drainage unit typically ranging in size from ten to one hundred hectares. This precise micro-level classification allows development planners to design specific soil and water conservation structures tailored to localized community-scale needs.

174. (A) P-4, Q-1, R-2, S-3
Water harvesting and conservation techniques have distinct functional roles. The Broad Bed and Furrow layout manages in-situ moisture while facilitating safe runoff disposal. Lining farm ponds with materials like HDPE minimizes seepage losses. Life-saving irrigation targets minimal water application during critical stress stages, while compartmental bunding enhances in-situ moisture retention across flat, mildly sloped fields.

175. (D) Drought avoidance
Drought avoidance is a specialized physiological adaptation where plants maintain high internal tissue water potential despite soil moisture deficits. This is achieved through traits that optimize water balance, such as deep, extensive root systems that maximize water uptake, or thick cuticular wax layers and stomatal sensitivity that minimize transpirational water loss, delaying cellular dehydration during dry spells.

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176. (C) Harvesting the stunted standing crop immediately to utilize as livestock fodder
During extreme and prolonged mid-season dry spells where crop failure is imminent, standard management options become unviable. In such scenarios, the most effective salvage strategy is to harvest the stunted standing crop immediately for livestock fodder. This proactive measure prevents complete economic loss, provides crucial animal feed during droughts, and clears fields for potential contingency crops.

177. (B) The Markov chain probability model
The Markov chain probability model is widely utilized in dryland agro-meteorology to analyze rainfall patterns. This mathematical tool calculates the probability of occurrence of wet and dry spells based on the weather state of preceding weeks. It provides critical, statistically sound guidance for determining optimal sowing dates, cropping patterns, and localized agricultural planning.

178. (B) I, III and IV
Evapotranspiration management is essential for conserving dryland moisture. Synthetic clear mulches reduce soil evaporation but can excessively heat the topsoil. Windbreaks and shelterbelts reduce advective energy loads, lowering regional crop water loss, while organic mulches improve soil structure. However, stomatal-closing antitranspirants reduce both transpiration and photosynthesis, making the claim that they increase both completely incorrect.

179. (A) Construction of check dams and gully plugs
Within integrated watershed management, the construction of check dams and gully plugs is a vital drainage line treatment. These structures are designed to intercept and slow down the high velocity of channelized surface runoff within active gullies. By reducing water speed, they prevent severe soil erosion, trap sediment, and promote localized groundwater recharge.

127. (C) A is true but R is false.
Thiourea is widely used as a foliar spray on rainfed crops during drought spells to improve stress tolerance. It contains a sulfhydryl group that enhances physiological activity, carbohydrate translocations, and photosynthetic rates under stress. However, thiourea is a plant growth regulator and chemical coordinator, not a herbicide, making the claim of weed control entirely false.

128. (C) Mid-season corrections are generally rigid and cannot be altered regardless of subsequent rainfall events
Contingency crop planning provides flexible, reactive strategies designed to mitigate the impact of weather abnormalities. When the monsoon withdraws early, harvesting crops for fodder serves as a practical salvage mechanism. Mid-season corrections must remain highly flexible, allowing farmers to continuously adapt their agronomic management and crop choices based on subsequent rainfall events and soil moisture dynamics.

129. (B) The ratio of precipitation to potential evapotranspiration over time
Calculating the Length of Growing Period according to the Food and Agriculture Organization methodology requires specific meteorological parameters. It is defined as the continuous period during the year when available water exceeds half of the potential evapotranspiration. Therefore, the ratio of precipitation to potential evapotranspiration over time is absolutely essential for determining this period.

130. (A) III, I, II, IV, V
Hydrological movement in a macro-watershed follows a strict sequential pathway. The process initiates when precipitation is received across the catchment area. This is followed by in-situ infiltration within the micro-catchments. Excess water then flows through localized drainage lines and gullies, where it is intercepted by gully plugs and check dams, eventually accumulating in the terminal reservoir.

131. (B) Poor moisture retention capacity and severe surface crusting
Alfisols, commonly found in semi-arid regions, present distinct biophysical challenges for agricultural production. These soils possess coarse texture, low organic matter, and weak structural stability. Consequently, they suffer from poor moisture retention capacity and are highly prone to severe surface crusting upon drying, which significantly impedes seedling emergence and reduces rainfed crop yields.

132. (C) Adequate soil moisture is necessary for the dissolution, movement, and efficient root uptake of applied nitrogen
Synchronizing nitrogen top-dressing with active rainfall events is a fundamental rule in rainfed agriculture. Soil moisture is absolutely vital for dissolving granular fertilizers and facilitating their movement into the root zone. Applying nitrogen during dry periods leads to severe volatilization losses and prevents roots from absorbing the nutrient, reducing overall fertilizer use efficiency.

133. (D) A prolonged period of statistical deficiency in precipitation relative to the long-term regional expected average
Meteorological drought is defined strictly by atmospheric and precipitation parameters. It refers to a prolonged period during which the actual rainfall received in a region is significantly lower than the long-term climatological expected average. Unlike agricultural or hydrological droughts, its measurement relies solely on meteorological records of precipitation deficits over a specific area.

134. (A) Index of Moisture Adequacy (IMA)
The Index of Moisture Adequacy is calculated as the ratio of actual evapotranspiration to potential evapotranspiration. This ratio serves as a vital indicator of water supply sufficiency relative to atmospheric demand. A high index value indicates that the crop's water requirements are well met, whereas lower values signify severe moisture stress and potential yield reduction.

135. (B) Applying materials like kaolin to increase leaf albedo, reducing radiation load, leaf temperature, and transpiration
Reflectants are specialized materials utilized in dryland agriculture to mitigate transpirational water loss. Spraying substances like kaolin clay onto crop foliage increases leaf albedo, which reflects a high percentage of incoming solar radiation. This process lowers leaf temperature and reduces the vapor pressure gradient between

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189. (D) A is false but R is true.
Cultivating long-duration, photoperiod-sensitive varieties is a poor strategy for regions with short, erratic growing periods. These crops inevitably expose their sensitive reproductive stages to severe terminal drought when the monsoon withdraws early. Under these conditions, short-duration varieties are far superior because they successfully complete their growth cycle before moisture is depleted.

190. (C) Mid-season corrections are rigid and must be applied regardless of actual weather conditions once planned
Mid-season agronomic corrections are flexible, dynamic interventions designed to manage weather aberrations. Practices like crop thinning reduce transpirational demand, while timely weed control prevents competition for limited moisture. Delivering life-saving irrigation targets critical growth stages to maximize water-use efficiency. These corrections must never be rigid; they are continuously modified based on real-time weather changes.

191. (D) It acts as a compatible osmolyte, facilitating osmotic adjustment and protecting sub-cellular structures from dehydration
Under severe drought stress, plants accumulate high concentrations of the amino acid proline. Proline functions primarily as a compatible osmolyte, facilitating osmotic adjustment by lowering cellular osmotic potential without interfering with normal enzyme functions. Additionally, it helps stabilize subcellular structures, scavenge reactive oxygen species, and protect vital cellular membranes from dehydration-induced damage.

192. (C) The Thornthwaite Moisture Index
The Thornthwaite Moisture Index is a quantitative aridity index used in climate classification. It defines climatic zones by calculating the precise balance between precipitation and potential evapotranspiration. This index measures water surplus or deficit relative to evaporative demand, allowing climatologists to systematically categorize regions as arid, semi-arid, sub-humid, or humid based on annual moisture adequacy.

193. (A) P-2, Q-1, R-4, S-3
Soil and water conservation structures have specific topographic applications. Contour bunds provide widespread in-situ moisture retention across mild slopes. Check dams are constructed across gullies to intercept channelized flows. Percolation tanks are situated on highly permeable soils to maximize groundwater aquifer recharge, while lined farm ponds store surface runoff for subsequent, crucial life-saving irrigation.

194. (D) Socio-economic drought
Socio-economic drought is a specialized classification of drought. Unlike meteorological or agricultural droughts, it is defined specifically by a physical shortage of water beginning to directly affect the supply and demand of essential economic goods. This imbalance negatively impacts human well-being, livestock health, industrial production, and overall economic stability in the affected region.

195. (B) II, IV, I, III, V
Hydrological units in watershed management are categorized hierarchically based on their geographical area. The standard sequence, starting from the largest macro-scale to the smallest micro-scale, begins with the macro-watershed. This is followed by the sub-watershed, then the mili-watershed. The classification continues down to the micro-watershed, and finally concludes with the mini-watershed.

196. (A) I, II and IV
Mulching techniques are highly effective for conserving soil moisture in dryland agriculture. Dust mulching breaks capillary channels to reduce evaporation, while organic stubble mulches moderate soil temperatures and suppress weeds. In contrast, synthetic clear plastics can excessively heat the soil, and stubble mulches function to minimize rather than increase raindrop impact velocity.

197. (A) The rapid formation of a hard surface crust upon drying that physically impedes seedling emergence
The most critical biophysical soil constraint affecting early crop establishment in dryland alfisols is soil crusting. Upon drying, the dispersed soil particles form a hard, structural surface crust. This dense layer physically impedes the emergence of young crop seedlings. Consequently, it leads to poor germination rates, uneven crop stands, and a significantly reduced plant population.

NODIA

CHAPTER 05
Crop Production in Problem Soils

2007

1. According to the standard classification of problem soils, which electrical conductivity (EC_e) and exchangeable sodium percentage (ESP) thresholds define a saline-sodic soil?
(A) $EC_e < 4$ dS/m, $ESP > 15$, $pH > 8.5$
(B) $EC_e > 4$ dS/m, $ESP > 15$, $pH < 8.5$
(C) $EC_e > 4$ dS/m, $ESP < 15$, $pH < 8.5$
(D) $EC_e < 4$ dS/m, $ESP < 15$, $pH < 8.5$

2010

2. Which primary pedogenic process is responsible for the extensive formation of saline soils in the arid and semi-arid regions of northwestern India?
(A) Podzolization accompanied by excessive leaching under humid conditions
(B) Continuous accumulation of basic igneous rock weathering products
(C) Intensive laterization leading to progressive silica depletion
(D) High evaporation exceeding precipitation coupled with poor drainage

2009

3. In the chemistry of soil acidity, salt-replaceable acidity is primarily composed of which exchangeable ions?
(A) Aluminum and hydrogen
(B) Hydrogen and magnesium
(C) Calcium and potassium
(D) Iron and manganese

2016

4. Which of the following is an INCORRECT statement regarding crop physiological responses to high soil acidity?
(A) Root elongation and development are severely inhibited by exchangeable aluminum toxicity.
(B) Excess manganese toxicity can easily induce physiological iron deficiency symptoms.
(C) Calcium deficiency is alleviated because hydrogen ions facilitate calcium uptake.
(D) Plant phosphorus availability is drastically reduced due to iron and aluminum fixation.

2019

5. If an acidic soil requires neutralizing, which liming material possesses the highest calcium carbonate equivalent (CCE)?
(A) Calcium oxide
(B) Calcium carbonate
(C) Calcium hydroxide
(D) Basic slag

2025

6. The initial phase of growth reduction in crops subjected to salt stress is primarily attributed to which specific mechanism?
(A) Direct sodium toxicity within expanding leaf tissues
(B) Excessive chloride accumulation in chloroplast membranes
(C) Competitive uptake inhibition of potassium by calcium ions
(D) Decreased osmotic potential of the soil solution

2011

7. Based on the relative crop yield decrement model, halophytes are distinguished from glycophytes primarily by their ability to do what?
(A) Selectively exclude toxic salt ions at the root endodermis barrier
(B) Compartmentalize high salt concentrations within cellular vacuoles
(C) Maintain low internal solute concentrations to avoid osmotic stress
(D) Sustain high transpiration rates regardless of soil salinity levels

2024

8. Which structural change correctly pairs with the mechanism of soil sodicity?
(A) Flocculation of clay micelles due to sodium dominance
(B) Enhanced hydraulic conductivity due to macro-pore expansion
(C) Breakdown of soil aggregates due to clay micelle dispersion
(D) Stabilization of organic matter complexes by sodium ions

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By utilizing localized water harvesting, it provides farmers with a stable source of income, improves nutritional security, and enhances overall ecological stability in rainfed regions.

207. (D) A is false but R is true.
Cultivating long-duration hybrids is highly risky and inappropriate for regions receiving less than 500 mm of highly erratic rainfall. These crops are highly vulnerable to complete failure because their growth cycle extends beyond the short rainy season, exposing reproductive stages to terminal drought. Consequently, only short-duration, drought-hardy varieties are recommended for these environments.

208. (C) The process generally results in a significant delay in field emergence and inherently weaker seedling vigor
Seed hardening is a precision agronomic tool involving controlled cycles of soaking and drying seeds before sowing. This pre-treatment induces favorable biochemical changes, enhancing physiological resilience under moisture stress. Consequently, hardened seeds exhibit faster, more uniform field emergence and stronger seedling vigor compared to untreated seeds, directly contradicting claims of delayed germination or weak seedling development.

209. (B) An area typically encompassing 100 to 1,000 hectares
In the context of Indian watershed management classifications, hydrological units are categorized by size to standardize planning. A micro-watershed is precisely defined as an area typically encompassing one hundred to one thousand hectares. This specific scale is ideal for planning community-level soil and water conservation projects, managing surface runoff, and implementing localized agronomic interventions.

210. (D) Replacing a calculated proportion of the main crop with the intercrop to balance density and resource use
A replacement series intercropping system is governed by specific spatial design principles. Unlike additive systems where the intercrop is added to a full-density main crop, a replacement series involves replacing a mathematically calculated proportion of the main crop with the intercrop. This balanced approach manages plant density, reduces inter-species competition, and optimizes overall resource use efficiency in drylands.

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2015

18. What is the primary agronomic rationale for employing a higher seed rate when establishing crops in degraded, problem soils?
(A) To induce early crop lodging for subsequent organic matter addition
(B) To rapidly deplete excess water logging through canopy transpiration
(C) To trigger intense intra-specific competition for toxic soil ions
(D) To compensate for expected low germination and seedling mortality

2016

19. The CSR series of rice varieties is specifically bred and released for tolerance to which type of environmental stress?
(A) Soil salinity and alkalinity
(B) Extreme drought
(C) Deepwater submergence only
(D) Aluminum toxicity in acid soils

2010

20. Match the crop species in List I with their general tolerance to specific soil conditions in List II:
List I: Crop species
P. Tea
Q. Sugarbeet
R. Rice
S. Barley
List II: General tolerance
1. Highly tolerant to soil salinity
2. Highly adapted to acidic soil conditions
3. Adapted to waterlogged conditions
4. Highly tolerant to soil sodicity
(A) P-1, Q-4, R-3, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-2, Q-4, R-3, S-1
(D) P-2, Q-3, R-1, S-4

2019

21. Which cropping system sequence is most commonly recommended for the gradual bio-amelioration of sodic lands in northern India?
(A) Sesbania (green manure) - Rice - Wheat
(B) Pearl millet - Mustard - Summer fallow
(C) Grain maize - Chickpea - Summer legume
(D) Fiber cotton - Sunflower - Rabi season

2012

22. Brackish irrigation water characterized by a high residual sodium carbonate (RSC) index poses which specific threat to soils?
(A) Promoting extensive soil acidification and aluminum leaching
(B) Inducing excessive leaching losses of critical micronutrients
(C) Causing rapid reduction of the overall soil redox potential
(D) Precipitating calcium and magnesium, increasing sodicity

2004

23. What defines the active acidity of a soil?
(A) The reserve of aluminum ions bound to clay surfaces
(B) The concentration of hydrogen ions in the soil solution
(C) The titratable acidity neutralized by strong bases
(D) The sum of basic cations on the exchange complex

2016

24. Which of the following is an INCORRECT statement regarding the current distribution of problem soils in India?
(A) The Indo-Gangetic plain holds a significant portion of sodic soils.
(B) Acid soils are predominantly found in the high rainfall areas of Northeast India.
(C) Coastal salinity is absent in the eastern states of India.
(D) Arid regions of Rajasthan feature widespread saline soils.

NODIA

2007

25. Which chemical species is the primary cause of residual soil acidity?
(A) Free carbonate and bicarbonate anions in soil solution
(B) Soluble chloride and sulfate salts in the root zone
(C) Exchangeable calcium and magnesium on active complexes
(D) Non-exchangeable aluminum and hydrogen on clays and humus

2018

26. High soil acidity leads to phosphorus fixation predominantly through the formation of which insoluble compounds?
(A) Insoluble aluminum and iron phosphates
(B) Insoluble calcium phosphate compounds
(C) Insoluble magnesium phosphate complexes
(D) Insoluble sodium polyphosphate salts

2004

27. What is the main advantage of using dolomitic limestone over calcitic limestone for ameliorating acidic soils?
(A) It reacts faster with soil acidity.

2021

9. Which INCORRECT pairing of a chemical amendment and its primary reaction mechanism in sodic soil reclamation is presented below?

(A) Gypsum : Supplies soluble calcium to replace exchangeable sodium

(B) Elemental sulfur : Undergoes biological oxidation to form sulfuric acid

(C) Sulfuric acid : Reacts with native calcium carbonate to release soluble calcium

(D) Iron pyrites : Directly replaces exchangeable sodium with iron

2008

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Green manuring with Sesbania aculeata is highly effective for the reclamation of sodic soils.

Reason (R): Sesbania aculeata adds significant organic matter but cannot mobilize native soil calcium carbonate.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

2016

11. What is the most appropriate indicator of intense reducing conditions in a waterlogged soil profile?

(A) An increase in oxidized nitrate concentrations within the soil solution

(B) A redox potential (E_h) drop below -200 mV with sulfide production

(C) A significant rise in redox potential (E_h) well above +400 mV

(D) The rapid chemical precipitation of iron as insoluble ferric oxide

2006

12. Which physiological adaptation is critical for crop survival under prolonged anoxia caused by waterlogging?

(A) Upregulation of stomatal conductance to maximize transpiration rates

(B) Formation of aerenchyma to facilitate internal oxygen transport

(C) Rapid accumulation of soluble sodium ions within root tissue vacuoles

(D) Enhanced metabolic synthesis of storage lipids within the taproot

2022

13. Subsurface (tile) drainage systems lower the water table primarily by utilizing which physical principle?

(A) Gravity-driven water flow into buried perforated drainage pipes

(B) Capillary movement of groundwater upward through soil micro-pores

(C) Substantial enhancement of evapotranspiration from the canopy

(D) Rapid diversion of excess surface runoff over the agricultural soil

2009

14. Calculating the leaching requirement (LR) for saline soils depends predominantly on which two parameters?

(A) Soil pH values and active exchangeable sodium percentage

(B) Total cation exchange capacity and soil organic carbon content

(C) Electrical conductivity of irrigation and drainage water

(D) Standard gypsum requirement and the saturated infiltration rate

2015

15. In sodic soils, specific ion antagonism most commonly leads to a deficiency of which essential nutrient?

(A) Nitrogen

(B) Phosphorus

(C) Molybdenum

(D) Zinc

2011

16. Which crop is widely utilized as an indicator for identifying visual symptoms of boron toxicity in salt-affected areas?

(A) Rice

(B) Cotton

(C) Sunflower

(D) Wheat

2002

17. Compared to flat planting, sowing seeds on the side of irrigation ridges in saline soils provides which distinct advantage?

(A) It positions the seeds in the zone of highest salt accumulation.

(B) It avoids the capillary concentration of salts at the ridge peak.

(C) It significantly increases the bulk density of the planting bed.

(D) It actively maximizes waterlogging stresses around seminal roots.

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198. (A) Both A and R are true and R is the correct explanation of A.
Dryland agronomy strongly advocates for the cultivation of short-duration, drought-escaping crop varieties. These varieties possess a rapid developmental rate, allowing them to complete their entire vegetative and reproductive lifecycles before the onset of predictable terminal dry spells. This specialized adaptation ensures stable yields by completely avoiding severe, late-season moisture deficits in rainfed regions.

199. (B) Farmers are advised to immediately increase the sowing density and fertilizer dosage of their traditional long-duration varieties
Contingency planning for a delayed monsoon aims to adapt cropping to a shortened growing period. Recommended practices include substituting long-duration varieties with short-duration pulses or millets, and pre-positioning seeds. However, increasing the sowing density and fertilizer dosage of traditional, long-duration varieties is highly inappropriate, as it increases transpirational demand and heightens the risk of crop failure.

200. (C) A cascade of failures including loss of turgor, stomatal closure, ceased cell expansion, and premature senescence
The physiological basis of drought syndrome in susceptible crops involves a cascade of metabolic and structural failures. Under severe moisture stress, plants experience initial loss of turgor pressure, which stops cell expansion and leaf elongation. This is followed by stomatal closure, a decline in photosynthetic activity, and the onset of premature leaf senescence, leading to plant death.

201. (D) To balance conserving in-situ moisture during dry spells with providing safe surface drainage during heavy rains
The Broad Bed and Furrow system is a specialized land management layout designed for deep, cracking vertisols. Its primary purpose is to balance water conservation and drainage. The raised beds store in-situ moisture and support crop growth during dry periods, while the intermediate furrows safely collect and drain excess surface runoff during heavy, erosive rainstorms.

202. (A) P-3, Q-2, R-4, S-1
Antitranspirants are categorized based on their specific physiological mode of action. Phenyl Mercuric Acetate functions as a stomatal-closing chemical. Silicone oils and hexadecanol act as film-forming agents by creating physical barriers. Kaolin powder serves as a reflectant material that increases leaf albedo, while Cycocel operates as a plant growth retardant, reducing shoot growth to conserve moisture.

203. (B) The likelihood of an event (like a wet week) given the state of the preceding period (like a dry week)
In agricultural rainfall probability analysis using the Markov chain model, conditional probability is a key parameter. It quantifies the likelihood of a specific weather event occurring, such as a wet week, given the meteorological state of the immediately preceding week. This analysis helps agronomists understand dry spell persistence and plan optimal sowing dates.

NODIA

204. (B) They restrict stomatal opening, reducing CO_2 influx and thereby lowering photosynthesis and yield
Stomatal-closing type antitranspirants present a major physiological disadvantage in field crop production. Although they successfully reduce transpirational water loss by inducing stomatal closure, this action physically restricts the influx of atmospheric carbon dioxide into the leaf. Consequently, it lowers the overall rate of photosynthetic carbon assimilation, which can significantly reduce crop biomass and final grain yield.

205. (A) I, II, IV and V
Nutrient management in drylands requires efficient strategies to overcome moisture constraints. Deep placement of basal fertilizer in the moist root zone is highly recommended. Top-dressing of solid nitrogen should coincide with rainfall, and split applications manage financial risk. Foliar urea application is highly effective during dry spells. However, applying fertilizers to dry surface soil is extremely inefficient.

206. (C) Dryland horticulture
Dryland horticulture is an integrated watershed management component that focuses on cultivating drought-hardy fruit trees on marginal lands. This system utilizes deep-rooted, drought-tolerant species like ber, pomegranate, or aonla.

(B) It supplies both calcium and magnesium.
(C) It has a much lower cost per unit of neutralizing value.
(D) It simultaneously reduces soil salinity.

2015

28. How does specific ion toxicity fundamentally differ from osmotic stress in salt-affected plants?
(A) Toxicity directly inhibits metabolic enzyme function, whereas osmotic stress physically restricts cell wall expansion.
(B) Toxicity stems from internal accumulation of Na^+ and Cl^- ions, while osmotic stress restricts root water uptake.
(C) Toxicity only affects plants during reproductive phases, while osmotic stress occurs strictly during germination stages.
(D) Toxicity is triggered solely by soil macronutrient ions, whereas osmotic stress is induced by trace micronutrient levels.

2021

29. If a crop demonstrates a 50% yield decrement at an EC_e of 6 dS/m, what can be inferred about its relative salt tolerance?
(A) It is moderately sensitive to moderately tolerant.
(B) It is classified as highly sensitive to salinity.
(C) It is a strict halophyte requiring salts for optimum growth.
(D) It possesses complete immunity to osmotic stress.

2003

30. Consider the following statements regarding the physical manifestations of soil sodicity:
I. Reduced hydraulic conductivity is caused by clay dispersion.
II. Soil crusting restricts seedling emergence.
III. Macroporosity significantly increases, aiding aeration.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and II
(D) I only

2025

31. The exact quantity of agricultural grade gypsum required to reclaim a sodic soil depends directly on which parameter?
(A) The total concentration of soluble chlorides in subsoil
(B) The percentage of active organic carbon in topsoil layers
(C) The active acidity of the soil solution in water suspension
(D) The difference between the initial and target soil *ESP*

2008

32. In the biological reclamation of sodic soils, the decomposition of press mud aids reclamation through which mechanism?
(A) Immediate precipitation of soluble salts under field conditions
(B) Neutralization of soil acidity via direct bicarbonate addition
(C) Production of organic acids that mobilize native calcium carbonate
(D) Directly substitution of sodium with potassium in the clay lattice

2004

33. Under waterlogged conditions, which sequence of microbial electron acceptors accurately reflects progressive soil reduction?
(A) Sulfate → Iron → Manganese → Nitrate → Oxygen
(B) Oxygen → Nitrate → Manganese → Iron → Sulfate
(C) Carbon dioxide → Sulfate → Iron → Oxygen → Nitrate
(D) Oxygen → Iron → Nitrate → Sulfate → Manganese

2004

34. Which physiological process correctly pairs with adventitious root formation in flooded crops?
(A) Active prevention of toxic sodium uptake by roots
(B) Maximization of phosphorus fixation on soil clays
(C) Accumulation of toxic hydrogen sulfide in root tips
(D) Enhanced oxygen capture near the surface water

2002

35. Comparing surface drainage and subsurface drainage, which statement is scientifically valid?
(A) Subsurface drainage manages water table and salinity levels in root zones.
(B) Surface drainage effectively lowers groundwater tables deeper than tile drains.
(C) Subsurface drainage requires precise slope grading of the entire field terrain.
(D) Surface drainage is primarily implemented to stop capillary rise in arid soils.

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2011

36. The leaching fraction in hydrological management is strictly defined as:
(A) The ratio of seasonal crop evapotranspiration to total applied water.
(B) The percentage of soluble salt precipitated directly in the root zone.
(C) The ratio of drainage water depth to applied irrigation water depth.
(D) The volume of water applied minus the amount lost to evaporation processes.

2011

37. Hidden hunger in crops grown on degraded soils refers to what phenomenon?
(A) Nutrient deficiency exists that reduces yield without explicit visual symptoms.
(B) The plant shows severe visual deficiency symptoms but maintains optimal yields.
(C) The growing soil lacks basic macronutrients but contains excess micronutrients.
(D) The crop absorbs excess nutrients leading to luxury consumption and toxicity.

2010

38. Visual diagnostic symptoms of iron deficiency induced by high calcium carbonate in calcareous soils typically manifest first as:
(A) Necrotic spots on older leaves
(B) Purpling of the leaf margins
(C) Upward curling of the lower leaves
(D) Interveinal chlorosis on the youngest leaves

2012

39. Adjusting planting geometry to utilize raised bed systems in salt-affected areas primarily results in:
(A) Complete biological elimination of root-zone soil salinity
(B) Better drainage and lateral salt displacement away from seeds
(C) Enhanced accumulation of salts directly under germinating seed
(D) Significantly faster depletion of active soil organic matter

2015

40. Consider the following agronomic interventions for crop establishment in saline soils:
I. Pre-sowing seed priming with salt solutions.
II. Upward adjustment of seed rates.
III. High-frequency irrigation with small depths of water.
IV. Delaying sowing to the hottest part of the season.
Which of the above practices are recommended?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I and III

2021

41. The KRL series of wheat varieties (e.g., KRL 19, KRL 210) are specifically classified as:
(A) Acid-tolerant varieties suited for lateritic soils
(B) Varieties bred strictly for deep-water flooding risks
(C) Varieties highly susceptible to Karnal bunt disease
(D) Salt-tolerant varieties for saline and sodic soils

2003

42. Oats and potatoes are capable of yielding well in acid soils largely because they:
(A) Tolerate high levels of soluble aluminum and manganese
(B) Require very high seasonal amounts of basic cations
(C) Rapidly neutralize the surrounding rhizosphere pH
(D) Excrete alkaline bicarbonate ions from their root tips

2013

43. Why is the inclusion of Dhaincha (Sesbania) in crop rotations critical for the gradual bio-amelioration of sodic lands?
(A) It requires highly saline irrigation water and specific soil types for survival.
(B) Acid root exudates and biomass decomposition lower soil pH and improve structure.
(C) It extracts toxic sodium ions and permanently sequesters them in leaf stems.
(D) It completely stops the downward percolation of water to lower clay horizons.

2016

44. What is a primary disadvantage of conjunctive use of canal water and high-salinity groundwater?
(A) Completely prevents the natural precipitation of calcium carbonate compounds.
(B) Requires careful EC monitoring of blended water to prevent soil salinization.
(C) Rapidly depletes local groundwater tables to critically low aquifer levels.
(D) Inherently reduces the active organic carbon content in the soil profile.

NODIA

2022
45. If a soil has a pH of 9.2, an EC_e of 2.5 dS/m, and an ESP of 25, it can be inferred that the soil structure is likely:
(A) Poorly structured with restricted soil permeability
(B) Well-aggregated and highly porous through the profile
(C) Characterized by extensive macropore networks in clays
(D) Highly resistant to physical surface crusting effects

2016
46. Which is a correct statement concerning the genesis of acidic soils in India?
(A) They form primarily in extremely arid regions where evaporation exceeds rainfall.
(B) They originate strictly from the physical weathering of calcium limestone bedrock.
(C) They form in high-rainfall regions due to the intense leaching of basic cations.
(D) They are the direct result of continuous capillary rise of alkaline groundwater.

2010
47. Which mechanism does NOT contribute to soil acidity?
(A) Nitrification of ammonium fertilizers
(B) Dissociation of organic acids from decomposing organic matter
(C) Hydrolysis of aluminum ions
(D) Accumulation of sodium carbonates

2009
48. In acidic soils, plant growth is generally NOT limited by:
(A) Severe nutritional calcium deficiency in root zone
(B) Heavy phosphorus deficiency from soil chemical fixation
(C) Excessive iron precipitation limiting availability
(D) High concentrations of active aluminum toxicity

2011
49. The lime requirement of an acid soil is calculated to neutralize which specific component(s)?
(A) Only the active acidity in the soil solution
(B) Both the active and exchangeable (reserve) acidity
(C) Only the residual acidity held within clay minerals
(D) The excess calcium and magnesium carbonates

2012
50. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): High concentrations of sodium in the soil solution reduce the uptake of potassium by crop roots.
Reason (R): Sodium and potassium compete for the same carrier sites and transport channels in the root plasma membrane.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006
51. Glycophytes respond to moderate soil salinity by exhibiting:
(A) Stunted growth, dark green leaves, and reduced leaf expansion
(B) Enhanced shoot elongation and rapid expansion of leaf area
(C) Rapid accumulation of soluble sodium ions inside chloroplasts
(D) Immediate physiological shedding of active root hair systems

2017
52. The breakdown of soil aggregates in sodic soils is chemically driven by:
(A) Strong chemical flocculating power of exchangeable calcium ions
(B) Direct precipitation of gypsum or soluble calcium sulfate salts
(C) Expansion of electrical double layers on clays by hydrated sodium
(D) Biological synthesis of highly persistent organic soil humus

2007
53. If elemental sulfur is applied to a calcareous sodic soil for reclamation, what must happen before it becomes effective?
(A) It must be biologically oxidized by Thiobacillus to form sulfuric acid.
(B) It must react directly with exchangeable sodium to produce sodium sulfide.
(C) It must dissolve in soil water to form sulfurous acid non-biologically.
(D) It must complex with soluble organic matter to precipitate native calcium.

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2016

54. The application of farmyard manure to salt-affected soils assists in reclamation primarily by:
(A) Adding massive, buffering quantities of exchangeable sodium ions
(B) Rapidly raising the pH of the soil solution to values above 10
(C) Directly decreasing the total cation exchange capacity of soils
(D) Improving soil structure, porosity, and facilitating salt leaching

2003

55. A dramatic shift in the redox potential (E_h) from +500 mV to -200 mV during soil waterlogging causes:
(A) Rapid biochemical oxidation of ammonium to nitrate forms
(B) Chemical reduction of sulfates to toxic hydrogen sulfide
(C) The precipitation of iron as insoluble ferric hydroxides
(D) A substantial decrease in overall solubility of manganese

2001

56. Compared to flood-sensitive crops, hypoxia-tolerant crops typically possess:
(A) Substantially lower rates of anaerobic glycolysis pathways
(B) A complete physiological inability to form adventitious roots
(C) Metabolic adaptations to avoid toxic ethanol build-up
(D) Possession of much thicker waxy cuticles on active roots

2024

57. The primary functional goal of surface drainage systems in agricultural fields is to:
(A) Lower the deep regional groundwater table to depths below 2 meters
(B) Leach highly soluble salts directly out of the active crop root zone
(C) Introduce gaseous atmospheric oxygen deep into wet subsoil horizons
(D) Safely and rapidly remove excess ponded water from soil surfaces

2004

58. Identify the INCORRECT statement regarding the hydrological management of saline soils.
(A) The leaching requirement decreases as the irrigation water salinity increases.
(B) Maintaining a downward hydraulic gradient is essential for salt balance.
(C) Artificial subsurface drainage is required if the natural water table is shallow.
(D) High-frequency irrigation helps dilute the salt concentration in the root zone.

2006

59. Induced zinc deficiency in crops grown on sodic soils is defined primarily by:
(A) Absolute physical absence of total zinc minerals in parent material
(B) Reduced solubility and availability of zinc at high soil pH levels
(C) Zinc chemical precipitation as zinc sulfide under aerobic conditions
(D) Zinc leaching excessively down into horizons below the active root zone

2013

60. Match the visual diagnostic symptom in List I with the most likely problem soil condition inducing it in List II:

List I: Visual diagnostic symptom
P. Marginal necrosis of older leaves due to chloride accumulation
Q. Interveinal chlorosis of young leaves due to iron immobility
R. Stunted root systems with brown, necrotic tips
S. General bronzing and toxicity spots on older leaves

List II: Problem soil condition
1. Aluminum toxicity in acid soils
2. Zinc/Iron deficiency in high pH calcareous sodic soils
3. Salinity stress (specific ion toxicity)
4. Iron toxicity in waterlogged acid soils

(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-2, R-1, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-3, Q-2, R-1, S-4

2024

61. From the agronomic recommendation to use high-frequency irrigation in saline soils, one can infer that:
(A) Moist soil profiles dilute osmotic concentration of the soil solution.
(B) Crop plants require significantly less total water under saline environments.
(C) High-frequency irrigation enhances upward capillary movement of salt ions.
(D) Irrigation water must be distributed solely via pressurized overhead sprinklers.

NODIA

2002

62. What is an advantage of seed priming with an osmoprotectant prior to sowing in salt-affected soils?
(A) It physically coats the seed coat with protective barriers to prevent water entry.
(B) It directly alters embryonic genome expression to act like a true halophyte.
(C) It triggers pre-germinative metabolic steps, ensuring faster, uniform emergence.
(D) It actively removes toxic native salts from the soil zone surrounding the seed.

2018

63. The mechanism of salt tolerance in the CSR series of rice involves:
(A) Complete physiological avoidance of sodium uptake by active root cell membranes
(B) Excretion of excess salts through specialized epidermal leaf glands on shoots
(C) Metabolic conversion of toxic sodium into volatile non-toxic gaseous forms
(D) Selective potassium uptake and compartmentalization of sodium in older leaves

2001

64. Which of the following is NOT a physiological strategy used by acid-tolerant crop varieties?
(A) Secretion of organic acids (e.g., citrate) from roots to chelate aluminum
(B) Increased pH in the rhizosphere due to nitrate uptake
(C) Precipitation of aluminum internally as aluminum carbonate crystals
(D) Internal detoxification of aluminum by binding it to organic ligands

2004

65. In a rice-wheat cropping system managed for sodic soil reclamation, the inclusion of a green manure crop during the summer gap provides:
(A) Rapid and significant lowering of the localized water table depth
(B) Biomass producing carbonic acid upon decay, aiding gypsum dissolution
(C) Total biological elimination of the need for mineral gypsum inputs
(D) Increased soil surface albedo, drastically lowering net evaporation

2006

66. The conjunctive use of high residual sodium carbonate (RSC) water and good quality canal water aims to:
(A) Increase total dissolved solids to improve water infiltration rates
(B) Maximize the chemical precipitation of exchangeable soil calcium
(C) Raise the pH value of canal water to match alkaline groundwater
(D) Dilute bicarbonate levels to prevent soil structure degradation

NODIA

2021

67. Which pair of soil classification parameter and its threshold is INCORRECTLY matched?
(A) Sodic soil : $EC_e > 4$ dS/m
(B) Saline soil : $EC_e > 4$ dS/m
(C) Sodic soil : $ESP > 15$
(D) Saline-sodic soil : $pH < 8.5$

2001

68. The largest area of salt-affected soils in India is geographically located in which state?
(A) Kerala
(B) Punjab
(C) Gujarat
(D) West Bengal

2005

69. Which component does NOT normally contribute to the active acidity measured by soil pH in water?
(A) Structural aluminum in internal clay lattices
(B) Dissolved carbon dioxide gas within soil pores
(C) Dissociated active organic acids in soil solution
(D) Soluble free hydrogen ions on exchange complexes

2002

70. Consider the following statements regarding crop responses to soil acidity:
I. Molybdenum availability increases at low pH.
II. Legume nodulation is severely suppressed.
III. Calcium and magnesium deficiencies are common.
Which of the above statements is/are INCORRECT?
(A) I only
(B) I and II
(C) II and III
(D) I and III

2024

71. The neutralizing value of a liming material is expressed relative to which standard chemical compound?
(A) Calcium hydroxide

(B) Pure calcium carbonate
(C) Calcium sulfate
(D) Calcium chloride

2004

72. During specific ion toxicity, boron accumulation in plants typically results in tissue necrosis first appearing in the:
(A) Root tip meristems under the soil
(B) Basal portion of the main stem
(C) Margins and tips of older leaves
(D) Freshly expanding youngest leaves

2016

73. Based on salt tolerance, crops are classified into sensitive, moderately sensitive, moderately tolerant, and tolerant groups. Which crop is correctly classified as tolerant?
(A) Beans
(B) Corn (Maize)
(C) Apple
(D) Barley

2022

74. Sodic soils exhibit poor aeration primarily because:
(A) Dispersed clay particles clog macropores, forming an impermeable matrix.
(B) Exchangeable sodium reacts directly with soil oxygen to yield sodium oxides.
(C) Extremely high pH directly degrades gaseous oxygen molecules in soil air.
(D) Excessive density of active plant root growth physically compacts the soil.

2008

75. Compared to agricultural grade gypsum, the application of iron pyrites for sodic soil reclamation is heavily dependent on:
(A) Immediate physical solubility of the applied material in cold water
(B) Presence of native soil lime to react with the produced sulfuric acid
(C) Extremely high levels of organic matter to initiate sulfur reaction
(D) Simultaneous application of agricultural lime to raise overall pH

2009

76. From the practice of incorporating green manure in sodic soils, it can be inferred that:
(A) Organic matter application severely worsens soil physical structure in fields.
(B) Biogenic CO_2 and organic acids help dissolve $CaCO_3$ to replace exchangeable Na^+.
(C) Active biological activity is entirely unnecessary for sodic reclamation.
(D) Green manure crops directly absorb all soluble sodium from soil profiles.

2011

77. The reduction of iron in a waterlogged soil refers to the chemical transformation of:
(A) Fe^{3+} to Fe^{2+}
(B) Fe^{2+} to Fe^{3+}
(C) Fe to Fe_2O_3
(D) FeO to $FeCO_3$

2003

78. Which statement correctly describes a primary morphological adaptation of wetland rice to excess water?
(A) Shedding of all active foliage to dramatically reduce transpiration losses
(B) Development of extremely deep taproots to reach oxygenated subsoil levels
(C) Formation of continuous interconnected gas spaces (aerenchyma) in tissues
(D) Accumulation of highly toxic levels of malate within root cortex tissues

2023

79. A distinct disadvantage of subsurface tile drainage compared to surface drainage is:
(A) It permanently removes land from cultivation due to deep trenches.
(B) It causes severe soil erosion during high rainfall events.
(C) It increases the salinity of the surface soil layer.
(D) The high initial capital cost of installation and maintenance.

2017

80. Consider the following factors concerning hydrological management of saline soils:
I. Leaching must be done with water of lower salinity than the desired soil solution.
II. Proper subsurface drainage must exist.
III. Evaporation should exceed infiltration during the leaching process.
IV. Salts must be transported below the active root zone.
Which of the above statements are INCORRECT?
(A) I and II
(B) II and III
(C) I and IV
(D) III only

2001

81. Which strategy eliminates hidden hunger most effectively in crops grown on problem soils?

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(A) Applying massive, continuous doses of standard nitrogen fertilizers alone
(B) Routine soil testing and targeted foliar spray of deficient micronutrients
(C) Relying solely on physical visual diagnosis of late-stage deficiencies
(D) Reducing irrigation frequency to concentrate nutrients in soil solutions

2022
82. Which specific indicator crop is widely known to show early and distinct visual symptoms of copper deficiency in degraded organic soils?
(A) Rice
(B) Tomato
(C) Sugarcane
(D) Wheat

2010
83. The conceptual basis for using a raised bed system with furrow irrigation in saline soils is that:
(A) Salts migrate to the bed top, letting seeds planted on shoulders avoid salinity.
(B) Soluble salts are continuously washed and deposited directly over the seed rows.
(C) The raised bed structure becomes heavily waterlogged, diluting profile salts.
(D) The furrow bottom zone accumulates absolutely no harmful salts during season.

2011
84. The cause of reduced germination percentage in saline soils is primarily due to:
(A) Specific toxic ion effect of phosphorus accumulation
(B) Severe physical hardening of external seed coat layers
(C) Water deficit at imbibition due to low osmotic potential
(D) Excessive oxygen availability in compacted seedbeds

2016
85. Which of the following is an exception to the general traits of highly salt-tolerant crop varieties?
(A) Inability to exclude sodium at the root surface
(B) High ability to compartmentalize sodium in vacuoles
(C) Maintenance of high tissue potassium-to-sodium ($\frac{K^+}{Na^+}$) ratios
(D) Synthesis of compatible organic solutes for osmotic adjustment

2021
86. Which acid-tolerant crop species is highly responsive to specific liming practices that neutralize exchangeable aluminum while maintaining a slightly acidic pH?
(A) Alfalfa
(B) Cotton
(C) Barley
(D) Potato

2011
87. In a systematic classification of crop rotations for bio-amelioration of salt-affected lands, the inclusion of a deep-rooted crop serves to:
(A) Rapidly deplete all available surface soil moisture levels
(B) Open up dense subsoil layers and improve water permeability
(C) Add exceptionally large quantities of surface crop litter
(D) Accumulate toxic salts permanently within the active root zone

2017
88. High RSC in irrigation water predominantly causes an increase in which soil parameter over time?
(A) Organic carbon content
(B) Total nitrogen
(C) Exchangeable sodium percentage
(D) Exchangeable acidity

NODIA

2018
89. Compared to sodic soils, saline soils generally exhibit:
(A) Significantly higher soil pH and lower active EC
(B) Significantly lower soil EC and higher active ESP
(C) Dark black crusts composed of dissolved organic matter
(D) Better physical structure and water permeability

2015
90. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The application of agricultural lime ($CaCO_3$) to sodic soils ($\{pH > 8.5\}$) is highly ineffective for reclamation.
Reason (R): Calcium carbonate is practically insoluble at high pH, thus failing to supply adequate calcium to replace exchangeable sodium.
(A) Both A and R are true and R is the correct

2012

109. The success of the KRL wheat series in sodic soils is physiologically driven by its ability to:
(A) Accumulate sodium heavily in the flag leaf to prevent cellular toxicity
(B) Drop its older leaves rapidly upon encountering toxic sodium levels
(C) Fix atmospheric nitrogen efficiently through symbiotic root associations
(D) Selectively exclude sodium and absorb potassium at the root interface

2019

110. Evaluate the following statements regarding acid-tolerant crops:
I. Tea requires highly basic soils for optimum flavor.
II. Oats can tolerate relatively high concentrations of active aluminum.
III. Potato is commonly grown in mildly acidic soils to suppress potato scab disease.
Which represents the correct combination of true statements?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2007

111. The rice-wheat cropping system is favored for sodicity bio-amelioration primarily because:
(A) Wheat requires continuous seasonal flooding, which effectively leaches surface salts.
(B) Rice cultivation involves puddling and ponding, facilitating sodium leaching.
(C) Both crops possess an absolute chemical requirement for sodium in their tissues.
(D) Wheat actively excretes strong mineral acids into the root zone to dissolve salts.

2004

112. If a farmer must use brackish irrigation water (high EC), one can infer that the agronomic management must include:
(A) Reducing the total irrigation volume to minimize cumulative seasonal salt addition
(B) Applying irrigation exclusively during periods of high mid-day evaporative demand
(C) Switching entirely to highly salt-sensitive crops to actively absorb excess salts
(D) Applying excess water over the crop requirement to ensure effective salt leaching

2022

113. A soil with pH 7.8, ECe 6.5 dS/m, and ESP 10 is classified as:
(A) Saline
(B) Sodic
(C) Saline-sodic
(D) Normal

2002

114. Which statement correctly links the geographical distribution of problem soils with their genesis?
(A) Coastal saline soils in Gujarat are formed through intense wind erosion and deposition of desert sands.
(B) Sodic soils of Uttar Pradesh are formed mainly by the weathering of acidic igneous parent rock material.
(C) Acid soils are concentrated in high-rainfall states due to intense leaching of basic cations.
(D) Saline soils of Rajasthan are formed by excessive canal irrigation and subsequent water table rise.

2025

115. Identify the component responsible for the reserve acidity of a soil.
(A) Aluminum and hydrogen ions bound on the cation exchange complex
(B) Carbonic acid dissolved in soil water under ambient CO_2 levels
(C) Free hydrogen ions suspended in the macro-pores of the soil
(D) Soluble organic acids released by root exudates and microbes

2017

116. Comparing calcium deficiency to aluminum toxicity in acidic soils, how do the root symptoms differ?
(A) Calcium deficiency causes rapid root thickening; aluminum toxicity causes extreme root elongation.
(B) Both cause rapid root branching and enhanced root hair development across the entire soil profile.
(C) Neither affects the root system directly but instead restricts vegetative shoot growth and leaf expansion.
(D) Calcium deficiency causes necrotic, gelatinous root tips that die back; aluminum toxicity causes stubby, swollen, and severely thickened roots.

2013

117. The concept of neutralizing value (NV) of a liming material dictates that:
(A) Materials with lower molecular weights

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2002

100. Match the reduced chemical species in List I with its corresponding oxidized form in soils in List II:

List I: Reduced chemical species

P. Fe^{2+}

Q. Mn^{2+}

R. H_2S

S. NH^{4+}

List II: Oxidized form

1. SO_4^{2-}
2. NO_3^-
3. Fe^{3+}
4. Mn^{4+}

(A) P-3, Q-2, R-1, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-1, Q-4, R-3, S-2

2001

101. A farmer applies nitrogen fertilizer to a severely waterlogged rice field. Applying nitrate-based fertilizer instead of ammonium-based fertilizer will likely result in:

(A) Rapid loss of nitrogen through denitrification to N_2 and N_2O
(B) Immediate uptake of nitrate leading to doubled crop yields
(C) Accumulation of highly toxic levels of nitrate in the soil
(D) Long-term chemical stabilization of nitrate in the root zone

2010

102. Identify the morphological adaptation that allows deepwater rice to survive prolonged submergence.

(A) Extreme thickening of the root cortex to block water entry
(B) Complete physiological cessation of all upward stem growth
(C) Formation of extensive physical root hairs on primary roots
(D) Rapid internode elongation keeping foliage above water

2013

103. Comparing surface and subsurface drainage, subsurface drainage is uniquely effective at:

(A) Diverting heavy surface runoff originating from high rainfall events
(B) Preventing upward capillary salt movement from shallow water tables
(C) Reducing the overall investment cost of initial field establishment
(D) Significantly increasing the active surface albedo of agricultural soil

NODIA

2019

104. The mathematical formula for Leaching Requirement (LR) in its simplest form is expressed as the ratio of:

(A) EC of drainage discharge to EC of incoming irrigation water
(B) Total crop evapotranspiration to localized depth of rainfall
(C) EC of irrigation water to the target EC of drainage water
(D) Active bulk soil ESP to irrigation water sodium adsorption SAR

2004

105. Nutrient imbalances in problem soils often cause reduced crop quality. High soil chloride levels are known to specifically reduce the burning quality of which crop?

(A) Wheat
(B) Sugarcane
(C) Potato
(D) Tobacco

2021

106. The visual diagnostic symptom of "bronzing" in rice is classically associated with the toxicity of which element in waterlogged soils?

(A) Aluminum
(B) Iron
(C) Boron
(D) Sodium

2016

107. Which tillage practice is eliminated or minimized in salt-affected soils to prevent bringing subsoil salts to the surface?

(A) Deep inversion plowing
(B) Shallow surface harrowing
(C) Zero tillage
(D) Ridge making

2022

108. Which is a negative consequence of adopting high-frequency irrigation in poorly drained saline soils?

(A) It dilutes the salt concentration in the upper soil layer.
(B) It maintains continuous moisture for the root system.
(C) It may exacerbate waterlogging and subsequent hypoxia.
(D) It reduces the matric suction of the soil.

2008

142. Comparing gypsum and elemental sulfur for reclaiming a calcareous sodic soil, which statement is true?
(A) Elemental sulfur is generally much faster acting and more soluble in soil water than gypsum.
(B) Both amendments provide soluble calcium directly to the soil solution upon physical dissolution.
(C) Gypsum supplies calcium directly; sulfur requires oxidation to dissolve native calcium.
(D) Neither amendment is chemically effective for reclamation if the soil pH is strictly above 8.5.

2012

143. Which statement accurately describes the role of farmyard manure in reclaiming sodic soils?
(A) It supplies large amounts of highly soluble sodium that actively competes with exchangeable sodium.
(B) It improves aggregation, increases infiltration, and releases pH-lowering organic acids.
(C) It chemically acts as a strong inorganic mineral acid to dissolve insoluble carbonated salts.
(D) It seals the upper soil surface layer, effectively preventing any further capillary salt accumulation.

2009

144. Waterlogging is formally defined in soil science as the condition where:
(A) Soil moisture is maintained exactly at field capacity throughout the active growing season.
(B) The shallow water table is infinitely deep, but the soil surface remains continuously wet.
(C) Long-term atmospheric evaporation significantly and consistently exceeds annual precipitation.
(D) All soil pores are filled with water, restricting gas exchange with the atmosphere.

2004

145. The concept of anoxia tolerance in crop plants primarily centers on the metabolic switch from aerobic respiration to:
(A) Ethanolic fermentation
(B) Photosynthetic carbon fixation in the roots
(C) Lipid beta-oxidation
(D) Photorespiration

2001

146. A critical design parameter for subsurface tile drainage systems is the "drain spacing". This spacing is primarily determined by:
(A) The specific botanical family of the crop harvested during the previous agricultural year.
(B) The physical color and organic matter percentage of the topsoil in the field.
(C) Soil hydraulic conductivity and depth to the impermeable layer.
(D) The average daily wind speed and aerodynamic resistance measured across the field.

2004

147. Which variable is eliminated from the calculation of the simple leaching fraction if steady-state conditions are assumed?
(A) Changes in soil salt storage over time
(B) Electrical conductivity of the irrigation water
(C) Electrical conductivity of the drainage water
(D) Volume of deep percolation

2021

148. The hidden hunger for zinc in sodic soils causes economic loss primarily because:
(A) Affected plants die immediately upon emergence from the soil surface due to acute cellular collapse.
(B) Soluble zinc becomes highly toxic and completely kills beneficial rhizosphere microflora populations.
(C) It causes the crop to lodge heavily prior to physical harvest due to weakened lignified stem tissue.
(D) Yield declines significantly before visual symptoms prompt fertilizer application.

2016

149. The use of specific indicator crops like sunflower for boron toxicity falls under which broader classification of agricultural assessment?
(A) Quantitative chemical soil testing
(B) Qualitative visual diagnostics
(C) Destructive biomass analysis
(D) Remote sensing

2002

150. Evaluate the following tillage and planting methods for problem soils:
I. Deep plowing to invert saline subsoil to the surface.
II. Planting seeds on the sloping sides of ridges.
III. Using zero-tillage to maintain surface mulch

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than calcium carbonate generally have NVs strictly less than 100%.
(B) Pure calcium oxide (CaO) has a neutralizing value greater than 100% relative to pure calcium carbonate.
(C) The neutralizing value is independent of the material's chemical composition.
(D) Magnesium carbonate has a lower neutralizing value than calcium carbonate.

2010

118. An advantage of the osmotic adjustment mechanism in salt-stressed plants is that it allows water uptake to continue; a major disadvantage is that:
(A) It permanently opens the stomata, causing rapid water loss and severe cellular desiccation.
(B) It completely shuts down the light-dependent reactions of photosynthesis within the chloroplast.
(C) It diverts metabolic energy and carbon resources to synthesize compatible solutes.
(D) It blocks the root cell membranes from absorbing any essential plant macronutrients.

2011

119. The threshold ECe value (dS/m) typically used in relative yield decrement models to denote the onset of yield decline for a specific crop is known as the:
(A) Leaching fraction
(B) Osmotic baseline
(C) Yield intercept
(D) Salinity threshold

2005

120. Evaluate the physical effects of soil sodicity:
I. Reduced infiltration rate.
II. Surface crusting upon drying.
III. Poor soil aeration.
IV. Increased soil friability.
Which represents the correct combination of symptoms?
(A) I, II and III
(B) I, II and IV
(C) I, III and IV
(D) II, III and IV

2004

121. The chemical definition of the Gypsum Requirement (GR) is:
(A) The total chemical amount of gypsum needed to neutralize the active and potential acidity of a soil.
(B) The amount of gypsum needed to replace exchangeable sodium from the soil root zone.
(C) The nutritional amount of gypsum required to supply adequate sulfur for optimum crop growth.
(D) The total volume of irrigation water required to completely dissolve 1 kg of agricultural gypsum.

2024

122. Farmyard manure (FYM) additions to sodic soils result in:
(A) Rapid chemical conversion of exchangeable sodium into a highly volatile gaseous state.
(B) An increase in soil CO_2 partial pressure, which lowers pH and dissolves native calcite.
(C) Permanent biochemical binding of exchangeable sodium into stable insoluble organic complexes.
(D) Immediate and complete elimination of the need for applying any chemical soil amendments.

2022

123. The accumulation of toxic levels of H2S in waterlogged soils occurs directly as a result of:
(A) The biological reduction of sulfate by anaerobic bacteria under low redox potentials.
(B) The chemical oxidation of elemental sulfur by aerobic autotrophic Thiobacillus bacteria.
(C) The slow abiotic hydrolysis of iron pyrites in well-aerated upper soil horizons.
(D) The direct catalytic reaction of molecular hydrogen gas with solid elemental sulfur.

NODIA

2011

124. From the observation that a crop forms hypertrophied lenticels under flooded conditions, one can infer that:
(A) The plant is suffering from severe physiological drought stress and osmotic imbalances.
(B) The plant is maximizing its structural salt excretion capacity through specialized glands.
(C) The plant is adapting to facilitate oxygen entry and vent toxic volatile metabolites.
(D) The plant is highly susceptible to aluminum toxicity under extremely low soil pH levels.

2004

125. The functional application of the Manning's equation in drainage engineering relates to:
(A) Calculating the cumulative rate of salt

leaching under steady-state water flow
(B) Measuring the hydraulic conductivity of the soil profile using the auger-hole method
(C) Estimating the free evaporation rate from a completely flooded agricultural field
(D) Determining the flow velocity of drainage water within open surface channels

2008

126. Identify the primary objective of managing the root-zone salt balance through leaching.
(A) To completely sterilize the soil profile of all pathogenic fungal and bacterial activity.
(B) To ensure the shallow groundwater table rises to within 50 cm of the active crop root zone.
(C) To maintain root-zone salinity below the threshold that causes economic yield decline.
(D) To accumulate basic exchangeable cations like calcium and magnesium for subsequent crops.

2023

127. Which condition is eliminated as a cause of iron chlorosis in crops grown on calcareous problem soils?
(A) High bicarbonate concentration in the soil solution of calcareous soils
(B) High absolute availability of soluble iron (Fe^{2+}) in the soil profile
(C) High bulk soil pH restricting the solubility of various iron compounds
(D) Immobilization of iron within the structural vascular plant tissues

2007

128. An indicator plant is defined agriculturally as a plant that:
(A) Yields the highest possible economic return per hectare under highly adverse conditions.
(B) Produces allelopathic chemicals that naturally suppress and kill surrounding weeds.
(C) Fixes the highest potential amount of atmospheric nitrogen via symbiotic pathways.
(D) Exhibits clear symptoms of nutrient deficiency or toxicity earlier than the main crop.

2021

129. Which pairing of planting geometry and its primary purpose in problem soils is INCORRECT?
(A) Furrow planting : Ensure seeds are placed in the zone of highest salinity
(B) Raised beds : Facilitate lateral salt movement away from the seed
(C) Ridge sowing (mid-slope) : Avoid high salt concentration at the ridge top
(D) Broad bed and furrow : Improve surface drainage and aeration

2018

130. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Seed priming with a 1-2% potassium nitrate solution improves crop establishment in moderately saline soils.
Reason (R): Potassium nitrate completely neutralizes the toxic sodium ions in the bulk soil solution.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

131. The CSR series of rice is technically defined by its inherent genetic capacity for:
(A) Sustaining growth and yield under salinity and alkalinity stresses
(B) Extreme drought avoidance through early maturity and rapid root extension
(C) Complete genetic resistance to all known fungal and bacterial pathogens
(D) Producing maximum yields exclusively under highly acidic upland soil systems

2023

132. The concept of crop rotation for bio-amelioration relies heavily on:
(A) Monocropping to establish a highly stable and specialized rhizosphere microflora.
(B) Leaving the soil completely fallow for extended periods to naturally leach surface salts.
(C) Burning all crop residues in the field to return soluble nutrient ash to the topsoil.
(D) Alternating deep-rooted tolerant crops with green manures to reduce soil ESP.

2023

133. The continuous conjunctive use of high RSC water without gypsum application will ultimately cause:
(A) A rapid and significant drop in soil pH below

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neutral levels.
(B) Precipitating calcium as calcium carbonate, raising the soil ESP.
(C) Enhanced availability and uptake of essential phosphorus and zinc.
(D) Massive downward leaching of all soluble basic exchangeable cations.

2003

134. An advantage of using electrical conductivity (ECe) to classify saline soils is its rapid, standardized measurement. A disadvantage is that:
(A) It provides no direct or indirect information regarding the active soil pH.
(B) It requires highly expensive and specialized mass spectrometry laboratory equipment.
(C) It cannot differentiate between the specific ions contributing to salinity.
(D) It only measures the gaseous phase and volatile compound concentrations of the soil.

2013

135. The formation of inland saline soils in semi-arid regions is broadly classified under which pedogenic regime?
(A) Podzolization driven by intense organic acid leaching in cold, humid climates.
(B) Calcification leading exclusively to the formation of calcium carbonate hardpans.
(C) Gleization driven by permanent deep-water flooding and anaerobic soil conditions.
(D) Salinization driven by capillary rise from a shallow, saline water table.

2011

136. Which factor is NOT considered a source of hydrogen ions in soil acidity?
(A) Weathering of limestone parent material
(B) Carbonic acid formed from root respiration
(C) Oxidation of elemental sulfur
(D) Hydrolysis of aluminum species

2023

137. Which specific physiological malfunction occurs in plants subjected to severe calcium deficiency in acidic soils?
(A) Rapid shedding of mature, healthy lower leaves due to accelerated senescence.
(B) Failure of terminal bud development and cell wall collapse in expanding tissues.
(C) Excessive starch and soluble carbohydrate accumulation in the main vascular stem.
(D) Thickening and heavy suberization of the protective root epidermal cuticle.

2009

138. Identify the parameter used to calculate the exact amount of agricultural lime required to reach a target soil pH.
(A) Electrical conductivity of the saturated paste extract
(B) Buffer pH or exchangeable acidity of the soil
(C) Total soil organic matter content alone
(D) Total sand percentage of the mechanical fraction

2022

139. In the context of salt stress, what is the primary consequence of nutrient ion competition at the root absorption sites?
(A) Induced deficiency of K+ and Ca2+ due to high Na+ concentrations.
(B) Excessive luxury consumption of K+ by the active root transport systems.
(C) Complete and permanent stoppage of all leaf transpiration processes.
(D) Rapid biochemical conversion of soil nitrates to volatile ammonia gas.

2014

140. Match the crops in List I with their corresponding threshold salinity classifications in List II:

List I: Crops
P. Cotton
Q. Wheat
R. Groundnut
S. Date palm

List II: Threshold Salinity Classification
1. Tolerant (High threshold)
2. Moderately Tolerant
3. Sensitive (Low threshold)
4. Highly Tolerant

(A) P-2, Q-4, R-1, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-4, Q-3, R-2, S-1

2024

141. Based on the chemical behavior of sodium on clay surfaces, it can be inferred that reducing the ESP of a sodic soil requires:
(A) Completely removing humified organic matter from the active soil clay complex.
(B) Thermally heating the bulk soil to evaporate the toxic exchangeable sodium.
(C) Applying highly basic materials to raise the soil pH well above neutral levels.
(D) Using a divalent cation like calcium to displace exchangeable sodium.

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explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024
91. The statistics of salt-affected soils in India indicate that approximately how much total area is affected by salinity and sodicity combined?
(A) ~1.2 million hectares
(B) ~6.7 million hectares
(C) ~25 million hectares
(D) ~40 million hectares

2022
92. The active acidity of a soil is defined operationally as the acidity measured by:
(A) Extraction with 1N KCl
(B) A *pH* meter in a soil-water suspension
(C) Titration of the soil with a strong acid
(D) Soil testing methods that measure undissociated organic acids

2003
93. A conceptual model of aluminum toxicity suggests that root growth stops primarily because:
(A) Aluminum binds to cell wall pectins and disrupts root apical meristem activity.
(B) Aluminum induces excessive and highly abnormal root hair cellular proliferation.
(C) Aluminum completely dissolves and degrades the outer protective root epidermis.
(D) Aluminum directly replaces elemental nitrogen during active amino acid synthesis.

2019
94. Identify the INCORRECT statement regarding the calculation of lime requirement.
(A) It depends heavily on the buffering capacity of the clay system.
(B) It considers the exact target *pH* required by the chosen crop species.
(C) It is determined solely by measuring active acidity in water.
(D) It must account for the CCE neutralizing value of the liming agent.

2021
95. From the mechanism of competitive nutrient ion uptake under salt stress, one can infer that:
(A) Applying massive amounts of sodium will actively enhance calcium uptake.
(B) Chloride ions significantly enhance the uptake of nitrate by plant roots.
(C) Salinity stress completely eliminates the plant's need for macronutrients.
(D) Applying supplemental potassium mitigates toxic effects of high sodium.

2006
96. A primary disadvantage of relying exclusively on the relative yield decrement model to classify plant salt tolerance is:
(A) It consistently overestimates the relative genetic tolerance of sensitive crop species.
(B) It only applies to aquatic plants grown under managed greenhouse hydroponic systems.
(C) It ignores environmental variables like humidity affecting transpiration and salt uptake.
(D) It requires knowing the exact genetic sequence and protein pathways of target crops.

2007
97. The reduction of hydraulic conductivity in a sodic soil occurs because:
(A) Soluble salts chemically precipitate and fill macro-pores.
(B) Clay swelling and dispersion block conducting soil pores.
(C) The soil active organic matter content increases drastically.
(D) Calcium ions strongly bind dispersed clay particles together.

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2002
98. Chemical amendments for sodic soils are classified into two broad groups: those that supply calcium directly, and those that:
(A) Supply sodium to exchange with clay calcium
(B) Supply magnesium to precipitate carbonates
(C) Absorb water to dry out wet soil profiles
(D) Generate acid to dissolve native soil lime

2017
99. The application of farmyard manure during chemical reclamation of a sodic soil causes an effect where:
(A) The efficiency of gypsum is enhanced through improved infiltration and biological activity.
(B) The organic acids produced neutralize the applied gypsum, rendering it useless.
(C) The *pH* rises further due to ammonia release.
(D) Soluble salts are permanently bound to the organic matter, eliminating the need for leaching.

and reduce evaporation.
IV. Puddling sodic soils extensively prior to wheat sowing.
V. Raised bed planting to improve drainage.
Which represents the INCORRECT combination of recommended practices?
(A) I, II and IV
(B) II, III and V
(C) I and IV
(D) I, IV and V

2009
151. An advantage of increasing the seed rate in saline soils is a guaranteed higher final plant stand. A major disadvantage is:
(A) The complete and rapid elimination of weed competition in the field.
(B) The absolute physiological failure of all planted seeds to germinate.
(C) The permanent and irreversible structural alteration of the clay matrix.
(D) Potential for severe intra-specific competition if germination is high.

2002
152. Which of the following is NOT a recognized mechanism utilized by acid-tolerant crop varieties to survive in low pH soils?
(A) Rapid synthesis of calcium carbonate in the roots.
(B) Chelation of toxic aluminum in the rhizosphere by organic root exudates.
(C) Sequestration of active aluminum ions within protective cellular vacuoles.
(D) Maintenance of a higher rhizosphere pH compared to the surrounding bulk soil.

2011
153. The inclusion of a green manure crop like Dhaincha in a rotation on sodic soils provides all the following benefits, EXCEPT:
(A) Addition of easily decomposable organic matter.
(B) Permanent increase in soil ESP.
(C) Mobilization of native calcium through CO_2 evolution.
(D) Significant increase in soil physical permeability.

2013
154. Identify the primary risk associated with the agronomic use of high-salinity brackish water without appropriate leaching.
(A) Rapid and irreversible acidification of the bulk soil profiles.
(B) Accumulation of soluble salts in the root zone, causing osmotic stress.
(C) Complete depletion of all available macronutrients from the root zone.
(D) Excessive weed growth that completely outcompetes the main crop.

2010
155. Arrange the following soil reclamation steps in the correct operational sequence for a severely sodic soil:
I. Application of gypsum.
II. Leveling and bunding of the field.
III. Ponding of water for leaching.
IV. Sowing of a tolerant crop (e.g., rice).
Which is the correct sequence?
(A) II, I, III, IV
(B) I, II, III, IV
(C) II, III, I, IV
(D) III, II, I, IV

2008
156. From the requirement to apply agricultural lime based on its calcium carbonate equivalent (CCE), one can infer that:
(A) All liming materials must be applied in identical physical weights to achieve neutralization.
(B) Only pure geological calcium carbonate can be utilized for neutralizing acidic farm soils.
(C) A material with $CCE > 100\%$ requires a lower application rate than calcium carbonate.
(D) CCE measures the exact chemical speed of the soil neutralization reaction in the field.

2011
157. Under extremely acidic conditions ($pH < 4.5$), which micronutrient frequently becomes highly available, often reaching toxic concentrations for crop plants?
(A) Molybdenum
(B) Calcium
(C) Boron
(D) Manganese

2002
158. Comparing the mechanisms of phosphorus fixation in different soils, how does fixation in acidic soils differ from that in calcareous soils?
(A) In acidic soils, P is fixed by active calcium; in calcareous soils, P is fixed by iron species.
(B) Phosphorus is strictly fixed in acidic soils, while it remains fully soluble in calcareous soils.

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(C) In acid soils, P is fixed by Fe/Al oxides; in calcareous soils, as Ca phosphates.
(D) Phosphorus is fixed primarily by humified organic matter complexes in both of these soil types.

2013
159. The exchangeable sodium percentage (ESP) is formally defined as:
(A) (Soluble Sodium / Total Cations) x 100
(B) (Exchangeable Sodium / Cation Exchange Capacity) x 100
(C) (Exchangeable Sodium / Exchangeable Calcium) x 100
(D) (Cation Exchange Capacity / Exchangeable Sodium) x 100

2004
160. Applying the relative crop yield decrement model, if the slope (b) for a crop is very steep, this indicates that the crop:
(A) Is highly tolerant to any increasing soil salinity levels above the established crop threshold.
(B) Yields significantly higher and grows more vigorously as the bulk soil salinity increases.
(C) Maintains a highly stable and unchanged crop yield regardless of the ambient soil salinity.
(D) Experiences rapid, severe yield drops with small salinity increases above the threshold.

2011
161. Which is an INCORRECT statement regarding the dynamics of soil sodicity?
(A) The electrical conductivity of sodic soils is always above 4 dS/m.
(B) High Exchangeable Sodium Percentage causes rapid dispersion of clay particles.
(C) Sodic soils typically maintain an alkaline pH value strictly greater than 8.5.
(D) Sodic soils exhibit extremely low water infiltration and percolation rates.

2005
162. Gypsum application is largely ineffective for the reclamation of coastal saline soils primarily because:
(A) Coastal soils completely lack humified organic matter required to bind calcium ions.
(B) Gypsum dissolves too rapidly when exposed to any amount of incoming seawater spray.
(C) Coastal soils have high permeability and the issue is soluble salts, not sodium.
(D) Gypsum reacts directly with soil chlorides to form highly toxic gaseous chlorine species.

NODIA

2012
163. The addition of farmyard manure to a reclaimed soil serves to sustain the reclamation because:
(A) The organic matter buffers against structural collapse and improves biological activity.
(B) It completely sterilizes the soil profile, preventing any potential weed seed germination.
(C) It chemically binds and removes all remaining soluble calcium from the lower soil profile.
(D) It instantly and effectively leaches all heavy metals out of the active root zone depth.

2003
164. In heavily waterlogged soils, which process is completely eliminated?
(A) Anaerobic fermentation
(B) Active methanogenesis
(C) Bacterial denitrification
(D) Aerobic respiration

2007
165. Arrange the following electron acceptors in the correct order of their sequential reduction as a soil becomes progressively waterlogged:
I. Nitrate
II. Oxygen
III. Sulfate
IV. Manganese
Which of the following represents the correct sequence?
(A) I, II, III, IV
(B) II, I, IV, III
(C) II, IV, I, III
(D) I, III, II, IV

2024
166. A crop variety that develops an extensive aerenchyma network strictly when exposed to flooding is exhibiting which classification of adaptation?
(A) Constitutive morphological adaptation
(B) Obligate cellular metabolic adaptation
(C) Inducible morphological adaptation
(D) Temporal avoidance through early maturity

2010
167. Identify the primary structural difference between surface and subsurface drainage systems.
(A) Surface systems utilize buried perforated pipes, while subsurface systems utilize open earthen trenches.
(B) Surface systems function through purely

biological pathways, while subsurface systems are strictly mechanical.
(C) Subsurface drainage systems do not require any physical discharge outlet to remove excess soil water.
(D) Surface systems alter topsoil channels; subsurface systems bury conduits below the root zone.

2019
168. An advantage of calculating the leaching fraction accurately is the conservation of irrigation water. A potential disadvantage of applying excessive leaching fractions is:
(A) Rising groundwater and excessive leaching of mobile nutrients.
(B) Complete and irreversible removal of all remaining soil moisture.
(C) Rapid and progressive increase in the exchangeable sodium percentage.
(D) Immediate and complete destruction of all soil organic matter.

2016
169. Specific ion antagonism in plant nutrition is defined as the process where:
(A) High concentration of one ion physically destroys root hair cells.
(B) High concentration of one ion inhibits root uptake of another.
(C) High concentration of two ions mutually assists joint root uptake.
(D) High concentration causes all ions to be rapidly exuded from roots.

2016
170. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Wheat plants grown on heavily limed acidic soils often exhibit visual symptoms of zinc and manganese deficiency.
Reason (R): Over-liming raises the soil pH excessively, which severely reduces the solubility and availability of most micronutrients.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014
171. The practice of "ridge and furrow" planting in salt-affected areas involves sowing seeds on the:
(A) Sloping shoulder of the ridge.
(B) Elevated top center of the ridge.
(C) Flooded bottom basin of the furrow.
(D) Deepest uncultivated part of subsoil.

2003
172. Comparing seed priming to high seed rates as agronomic interventions in saline soils:
(A) Both practices guarantee exceptionally high crop yields regardless of actual soil salinity levels.
(B) Seed priming actively removes salts from the soil, whereas using high seed rates adds organic matter.
(C) Priming improves germination vigor; high seed rates compensate statistically for mortality.
(D) Neither of these agronomic practices is recommended or utilized under modern farming operations.

2019
173. All of the following are recognized salt-tolerant crop varieties developed in India, EXCEPT:
(A) CSR 30 (Rice)
(B) KRL 210 (Wheat)
(C) CS 52 (Mustard)
(D) IR64-Sub1 (Rice)

2024
174. Which is a correct statement regarding the liming of acid soils?
(A) Liming decreases phosphorus availability by immediate calcium phosphate precipitation.
(B) The primary ecological goal of liming is to completely sterilize the soil microbiome.
(C) The frequency of liming depends on soil cation exchange and buffering capacity.
(D) Liming must be repeatedly performed every single month to sustain optimum crop results.

2015
175. The Residual Sodium Carbonate (RSC) of irrigation water is calculated using which of the following chemical formulas (where concentrations are expressed in meq/L)?
(A) $RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$
(B) $RSC = \dfrac{Na^+}{\sqrt{\dfrac{Ca^{2+} + Mg^{2+}}{2}}}$
(C) $RSC = (Ca^{2+} + Mg^{2+}) - (CO_3^{2-} + HCO_3^-)$
(D) $RSC = (Na^+ + K^+) - (Ca^{2+} + Mg^{2+})$

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2019

194. High-frequency irrigation in saline soils minimizes osmotic stress directly because:

(A) It chemically neutralizes the harmful exchangeable sodium ions present in soil.

(B) It physiological forces the crop plant to transpire at a significantly faster rate.

(C) It keeps soil moisture high, preventing salts from concentrating in small water volumes.

(D) It leaches all dissolved salts deep into the local groundwater aquifer instantly.

2013

195. Select the correct sequential strategy for establishing a crop in a moderately saline field:

I. Pre-sowing heavy irrigation (leaching).

II. Selection of relatively tolerant cultivars.

III. Seed priming.

IV. Sowing on the sides of ridges.

Which of the following represents the correct sequence?

(A) I, II, III, IV

(B) IV, III, II, I

(C) II, I, IV, III

(D) III, IV, I, II

2002

196. Identify the primary characteristic that makes certain tea clones highly adapted to acidic soils.

(A) They require a neutral pH above 7.0 for symbiotic nitrogen fixation.

(B) They rapidly raise the pH of the surrounding bulk rhizosphere soil.

(C) They possess shallow roots that actively avoid the acidic subsoil zone.

(D) They tolerate high internal concentrations of aluminum.

2018

197. The term "bio-amelioration" refers strictly to:

(A) The direct agricultural application of strong chemical mineral acids to dissolve soils.

(B) Using plants and organic decay to improve soil structure and remove salts.

(C) The mechanical crushing of dense subsoil clay hardpans using specialized deep tillage.

(D) The physical application of various synthetic soil conditioners such as polyacrylamide.

2007

198. The conjunctive use of brackish water with canal water has the advantage of expanding the total irrigation supply. What is its main disadvantage?

(A) It artificially purifies the shallow saline groundwater table too rapidly.

(B) It completely prevents any natural downward leaching process from occurring.

(C) It requires constant monitoring to prevent soil salinization and degradation.

(D) It makes the treated soil profile highly and permanently acidic over time.

2022

199. The measurement of soil pH is fundamentally a measurement of:

(A) The specific physical concentration of free hydroxyl ions exclusively.

(B) The total buffer reserve capacity of basic exchangeable cations.

(C) The chemical ratio of exchangeable calcium to magnesium on clays.

(D) The negative logarithm of hydrogen ion activity in soil solution.

2011

200. Evaluate the following statements regarding the genesis of problem soils:

I. Saline soils form mainly in arid/semi-arid regions.

II. Sodic soils often develop from prolonged use of high RSC water.

III. Acid soils form in high rainfall regions due to basic cation leaching.

IV. Waterlogged soils develop where drainage is severely restricted.

V. Calcareous soils form entirely from the accumulation of organic matter.

Which represents the correct combination of true statements?

(A) I, II, III and IV

(B) I, II, IV and V

(C) II, III, IV and V

(D) I, III, IV and V

NODIA

2007

201. The concept of "residual acidity" implies that:

(A) The active acidity can be easily washed away with a single heavy field irrigation.

(B) Non-exchangeable acidity bound to clay and humus, buffering against pH changes.

(C) The active acidity is completely benign and does not affect commercial crop growth.

(D) The chemical acidity only exists within the top two centimeters of the surface soil.

2025

202. Which symptom is primarily responsible for the failure of legume establishment in highly acidic soils?

(A) Excessive and luxury uptake of inorganic nitrogen from the surrounding soil.

expansion of vegetative plant roots.

2002

185. The "gypsum requirement" calculation is fundamentally defined by the need to lower the soil ESP to a target safe level, typically around:
(A) 50%
(B) 35%
(C) 25%
(D) 10%

2014

186. Which organic amendment is widely noted for its dual role as a bulky organic manure and a moderate soil acidifier due to its high sulfur content?
(A) Chopped rice straw residue
(B) Press mud (sulfitation)
(C) Well-matured compost
(D) De-oiled neem cake

2017

187. Applying the concept of soil redox potential (Eh), at approximately what Eh value does the reduction of sulfate to hydrogen sulfide typically commence in flooded soils?
(A) +400 mV
(B) +200 mV
(C) -150 to -200 mV
(D) -500 to -800 mV

2013

188. From the observation that a crop exhibits severe stunting and yellowing exclusively in low-lying, poorly drained patches of a field, one can reasonably infer that the primary stress is:
(A) Extreme physiological drought
(B) Severe acidic soil toxicity
(C) Hypoxia from waterlogging
(D) Heavy atmospheric wind damage

2012

189. Comparing the installation of surface drains versus subsurface tile drains:
(A) Surface drains completely and permanently control the seasonal groundwater table depth.
(B) Subsurface tile drains are significantly cheaper and much easier to regularly maintain.
(C) Subsurface drainage systems cause massive and irreversible physical topsoil erosion.
(D) Surface drains require land shaping; subsurface drains require high initial capital.

2002

190. Evaluate the following parameters involved in calculating the leaching requirement:
I. Electrical conductivity of the irrigation water (ECiw).
II. Permissible electrical conductivity of the drainage water (ECdw).
III. Cation exchange capacity of the soil.
IV. Volume of irrigation water applied.
V. Crop evapotranspiration rate.
Which represents the correct combination of parameters fundamentally required for the simplest steady-state LR calculation?
(A) I, II and IV
(B) I, III and V
(C) I and II
(D) II, IV and V

2006

191. Which of the following is NOT a consequence of specific ion antagonism in sodic soils?
(A) Excessive sodium inducing acute calcium deficiency.
(B) Enhanced phosphorus uptake from high zinc.
(C) Excessive sodium inducing acute potassium deficiency.
(D) Decreased activity of magnesium in the soil solution.

2005

192. Which plant is classically utilized as a visual diagnostic indicator for extreme soil acidity and associated aluminum toxicity due to its sensitive root growth?
(A) Rice
(B) Sugarcane
(C) Coconut
(D) Alfalfa

2010

193. The concept of using raised beds for salt avoidance is eliminated as an effective strategy if:
(A) Sprinkler irrigation washes accumulated salts from the bed top back into the root zone.
(B) The applied irrigation water is chemically pure and free of any dissolved ionic species.
(C) The crop is planted exclusively on the lower lateral shoulders of the constructed bed.
(D) The raised bed is physically constructed entirely of highly coarse coarse-textured sand.

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2017

176. When managing brackish irrigation water, one can infer that applying organic matter (like FYM) helps mitigate negative effects by:
(A) Completely precipitating all soluble chlorides and sulfates into insoluble solids.
(B) Reducing the total volume of brackish irrigation water required by up to 90 percent.
(C) Releasing high concentrations of free sodium ions back into the active root zone.
(D) Buffering soil structure against dispersion and maintaining infiltration rates.

2001

177. The Sodium Adsorption Ratio (SAR) of the soil solution is conceptually important because it predicts:
(A) The equilibrium ESP of the soil solid phase.
(B) The exact active pH value of the soil solution.
(C) The potential active acidity of the soil complex.
(D) The total amount of structural aluminum in clays.

2013

178. Which pedogenic process is eliminated as a cause of soil sodification?
(A) Accumulation of sodium carbonate from primary mineral weathering.
(B) Prolonged and continuous use of high RSC irrigation water.
(C) Intense leaching by high annual rainfall in mountains.
(D) Direct capillary rise of sodium-rich shallow groundwater.

2007

179. Active acidity in soils is formally defined as the concentration of:
(A) Hydrogen and aluminum ions adsorbed on the soil exchange complex.
(B) Hydrogen ions present in the active soil solution phase.
(C) Hydroxyl ions present in the active soil solution phase.
(D) Aluminum ions precipitated as solid aluminum hydroxide.

2014

180. Match the crop physiological response in List I with the soil condition causing it in List II:

List I: Crop Physiological Response
P. Aluminum toxicity halting root elongation
Q. Osmotic stress reducing water uptake
R. Hypoxia inducing aerenchyma formation
S. Zinc deficiency due to high pH

List II: Soil Condition
1. Saline soil
2. Calcareous Sodic soil
3. Acid soil
4. Waterlogged soil

(A) P-3, Q-1, R-4, S-2
(B) P-2, Q-4, R-1, S-3
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-3, R-2, S-1

NODIA

2002

181. A direct effect of applying a liming material with a low CCE compared to one with a high CCE is that:
(A) The low CCE material works significantly faster in highly buffered clay soils.
(B) A larger quantity of low CCE material is needed for the same pH change.
(C) The low CCE material will also effectively reclaim severely sodic soil profiles.
(D) The low CCE material will actively decrease the soil pH below current levels.

2006

182. A fundamental physiological mechanism of salt tolerance in halophytes is:
(A) The complete and active exclusion of all incoming water from the root system.
(B) The rapid biochemical conversion of toxic sodium into harmless potassium atoms.
(C) Accumulating inorganic ions in vacuoles to maintain a favorable osmotic gradient.
(D) The continuous shedding of all active vegetative foliage during salt stress.

2018

183. Based on salt tolerance classifications, which of the following crops is grouped under "highly sensitive"?
(A) Barley
(B) Cotton
(C) Sugarbeet
(D) Strawberry

2019

184. The advantage of clay micelle dispersion in some industrial applications is offset by its massive disadvantage in agriculture, which is:
(A) Destruction of soil aggregation, leading to surface crusting and poor aeration.
(B) Excessive and rapid downward drainage of essential plant-available water.
(C) The extremely rapid chemical volatilization of all humified soil carbon.
(D) The uncontrolled and abnormal physical

(B) Inhibited Rhizobium survival and nodulation due to low pH and aluminum.
(C) Premature reproductive flowering and subsequent early pod shattering in field.
(D) Rapid biochemical decomposition of the seed embryo prior to active germination.

2013
203. From the necessity to use a "liming factor" in agricultural lime calculations, one can infer that:
(A) Incomplete field mixing and slow dissolution require applying more than laboratory estimates.
(B) Pure geological calcium carbonate is always one hundred percent efficient under variable field operations.
(C) Standard laboratory buffer titration perfectly and seamlessly replicates dynamic field conditions.
(D) Agricultural lime is easily and rapidly lost to volatilization as gas into the upper atmosphere.

2010
204. Comparing the physiological effects of chloride toxicity and sodium toxicity in fruit trees:
(A) Both toxicities result exclusively in rapid root death and complete cellular collapse.
(B) Sodium toxicity occurs strictly in the winter, whereas chloride toxicity occurs in the summer.
(C) Chloride toxicity causes marginal leaf burn; sodium causes mottling and necrotic spots.
(D) Neither elemental toxicity causes any visible external symptoms until the crop tree dies.

2023
205. Arrange the following crops in decreasing order of their relative salt tolerance (from most tolerant to most sensitive):
I. Barley
II. Wheat
III. Chickpea
IV. Strawberry
Which of the following represents the correct sequence?
(A) II, I, IV, III
(B) IV, III, II, I
(C) III, IV, I, II
(D) I, II, III, IV

2013
206. Which statement is correct regarding the structural degradation of sodic soils?
(A) Physical degradation caused by native earthworms rapidly consuming all soil organic matter.
(B) Structural degradation that is completely and physically irreversible under any farm condition.
(C) Mutual repulsion of clay particles due to thick hydration shells of sodium ions.
(D) Soil structural degradation characterized by a significant increase in total soil pore space.

2022
207. The reaction of agricultural gypsum in a sodic soil containing calcium carbonate is classified chemically as a:
(A) Neutralization reaction
(B) Cation exchange reaction
(C) Precipitation reaction
(D) Redox reaction

2003
208. The beneficial effect of adding elemental sulfur to a sodic soil is eliminated if:
(A) The treated soil possesses an extremely high active clay content.
(B) The cultivated field is heavily and continuously irrigated with water.
(C) The target sodic soil already contains native calcium carbonate reserves.
(D) The soil is sterile and lacks sulfur-oxidizing bacteria.

2017
209. Under prolonged waterlogging, the concentration of soluble iron in the soil solution typically:
(A) Increases due to reduction of insoluble Fe3+ to soluble Fe2+.
(B) Decreases rapidly due to immediate precipitation of complex oxides.
(C) Remains completely unchanged regardless of the anaerobic condition.
(D) Drops to absolute zero within the first twenty-four hours of flooding.

NODIA

2004
210. A researcher wants to improve the anoxia tolerance of a sensitive crop. Conceptually, which metabolic pathway should be genetically enhanced?
(A) Triggering the complete biological shutdown of all cellular ATP production mechanisms.
(B) Accelerating the rate of the aerobic Krebs cycle in the presence of trace oxygen.
(C) Recycling NAD+ via controlled fermentation to maintain glycolysis during hypoxia.
(D) Promoting the rapid synthesis and

9. (D) Iron pyrites : Directly replaces exchangeable sodium with iron
Sodic soil reclamation requires chemical amendments that either supply calcium directly or dissolve native calcium carbonate. While gypsum supplies soluble calcium, elemental sulfur and sulfuric acid generate acidity to dissolve insoluble lime. However, iron pyrites do not directly replace exchangeable sodium with iron; instead, they must undergo biological oxidation to form sulfuric acid, which dissolves lime.

10. (C) A is true but R is false.
Green manuring with Sesbania aculeata is highly effective for reclaiming sodic soils due to its deep root system and biomass production. Upon decomposition, this green manure releases organic acids and carbon dioxide, which dissolve native calcium carbonate, releasing soluble calcium. Therefore, while its effectiveness is well-established, claiming it cannot mobilize native soil calcium carbonate is incorrect.

11. (B) A redox potential (E_h) drop below -200 mV with sulfide production
Waterlogged soils undergo a sequential depletion of oxygen and other electron acceptors, leading to highly reduced conditions. When the redox potential drops below negative two hundred millivolts, anaerobic microflora utilize sulfate as a terminal electron acceptor. This metabolic shift reduces sulfate to toxic hydrogen sulfide, which serves as a definitive indicator of an extremely reduced soil environment.

12. (B) Formation of aerenchyma to facilitate internal oxygen transport
Waterlogging causes severe oxygen deficiency in the root zone, prompting plants to develop crucial survival mechanisms. Intolerant crops perish, but adapted species undergo morphological transformations, specifically forming aerenchyma tissue. These continuous, gas-filled cellular pathways facilitate the internal transport of oxygen from the aerial shoots down to the roots, ensuring sustained respiration under anaerobic soil conditions.

13. (A) Gravity-driven water flow into buried perforated drainage pipes
Subsurface drainage systems, commonly utilizing buried perforated tile pipes, are installed to manage high water tables in agricultural fields. These systems operate on basic gravitational principles. When groundwater levels rise above the drain depth, water flows under gravity into the perforated pipes, which then convey the excess water away, lowering the water table in root zones.

14. (C) Electrical conductivity of irrigation and drainage water
The leaching requirement represents the fraction of applied irrigation water that must pass through the root zone to prevent excessive salt accumulation. Calculating this requirement relies primarily on salt balance principles. The determination depends on the electrical conductivity of the incoming irrigation water and the maximum permissible electrical conductivity of the drainage water based on crop salt tolerance.

15. (D) Zinc
Sodic soils exhibit high levels of exchangeable sodium and high pH, which severely alter nutrient availability. The alkaline conditions promote specific ion antagonism and chemical precipitation. Consequently, solubility and plant uptake of essential micronutrients are drastically suppressed. Among these, zinc deficiency is the most widespread and severe agronomic problem observed in crops cultivated on sodic lands.

16. (C) Sunflower
Salt-affected and arid soils often accumulate toxic concentrations of boron, which severely impairs crop growth and development. Identifying this toxicity early is vital for effective field management. Sunflower is widely utilized as a highly sensitive indicator plant because it exhibits clear, easily identifiable visual symptoms, such as necrotic spots and marginal leaf scorching, when exposed to excess boron.

17. (B) It avoids the capillary concentration of salts at the ridge peak.
Under furrow irrigation in saline soils, soluble salts migrate upward with water and concentrate at the peaks of ridges via capillary action. Sowing seeds directly on the shoulder or side of these irrigation ridges ensures that the germinating seedlings are positioned away from this zone of maximum salt accumulation, thereby facilitating better crop establishment and survival.

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ANSWERS

1. (B) $EC_e > 4$ dS/m, $ESP > 15$, $pH < 8.5$
Saline-sodic soils represent a transitional category of degraded soils containing high levels of both soluble salts and exchangeable sodium. According to the standard classification scheme, these soils are defined by an electrical conductivity greater than four decisiemens per meter, an exchangeable sodium percentage exceeding fifteen, and a soil reaction pH typically below eight point five.

2. (D) High evaporation exceeding precipitation coupled with poor drainage
The genesis of saline soils in the arid and semi-arid regions of northwestern India is primarily driven by hyper-arid climatic conditions. When evaporation rates vastly exceed precipitation, soluble salts dissolved in groundwater migrate upward via capillary action. Lacking adequate drainage or flushing, these salts accumulate permanently in the root zone and surface soil layers.

3. (A) Aluminum and hydrogen
In soil chemistry, salt-replaceable acidity represents the fraction of soil acidity that can be displaced into solution by a neutral, unbuffered salt solution. This component of active acidity is predominantly composed of exchangeable aluminum and hydrogen ions. These ions are held electrostatically on the exchange sites of clay minerals and organic matter within acidic environments.

4. (C) Calcium deficiency is alleviated because hydrogen ions facilitate calcium uptake.
High soil acidity negatively impacts plant physiology, particularly through toxic concentrations of aluminum and manganese. These trivalent aluminum ions severely restrict root cell division and elongation, hindering nutrient uptake. Furthermore, excessive hydrogen ion concentrations in the soil solution directly compete with basic cations at root absorption sites, which actively aggravates rather than alleviates calcium deficiency in plants.

5. (A) Calcium oxide
The effectiveness of a liming material is quantified by its calcium carbonate equivalent, which measures its neutralizing power relative to pure calcium carbonate. Calcium oxide, also known as burned or quick lime, has the highest calcium carbonate equivalent value because of its low molecular weight and high concentration of reactive oxide ions that efficiently neutralize active hydrogen.

6. (D) Decreased osmotic potential of the soil solution
The initial phase of crop growth reduction under salinity stress is predominantly a physical water-retrieval issue rather than chemical toxicity. High concentrations of dissolved salts in the soil solution significantly lower its osmotic potential. This decrease restricts the gradient required for roots to absorb water, effectively exposing the plant to an immediate, physiological drought-like condition.

7. (B) Compartmentalize high salt concentrations within cellular vacuoles
Halophytes possess specialized evolutionary mechanisms that distinguish them from glycophytes when exposed to highly saline environments. Instead of expelling or blocking all salts, halophytes accumulate and safely compartmentalize toxic sodium and chloride ions within their cellular vacuoles. This intracellular compartmentalization keeps the cytoplasm free of toxicity while maintaining a lower osmotic potential to facilitate water absorption.

8. (C) Breakdown of soil aggregates due to clay micelle dispersion
Soil sodicity is characterized by a high percentage of exchangeable sodium on the clay complex. Sodium has a large hydrated ionic radius and low charge, which expands the electrical double layer around clay micelles. This expansion causes the clay particles to repel each other, leading to aggregate dispersion and the complete collapse of soil physical structure.

NODIA

accumulation of toxic lactic acid in root cells.

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18. (D) To compensate for expected low germination and seedling mortality
Degraded and problem soils present hostile environments characterized by high salinity, sodicity, or acidity, which restrict crop establishment. These conditions naturally impair seed imbibition and suppress early seedling vigor, leading to poor emergence. Employing a higher seed rate is a standard agronomic recommendation designed specifically to compensate for this expected high mortality and ensure optimum plant population.

19. (A) Soil salinity and alkalinity
The CSR series of rice varieties, developed by the Central Soil Salinity Research Institute in India, represents a major breeding breakthrough. These genotypes are specifically selected and bred for high yield performance under salt stress. They possess superior physiological mechanisms that confer tolerance to both high soil salinity and alkaline or sodic soil conditions.

20. (C) P-2, Q-4, R-3, S-1
Different crop species exhibit specialized adaptations to specific soil constraints. Tea is highly adapted to acidic soils because it tolerates soluble aluminum. Sugarbeet is exceptionally tolerant of sodic conditions. Rice thrives in waterlogged soils due to its internal gas channels. Barley is classified as highly salt-tolerant, maintaining productive yields under high electrical conductivity levels.

21. (A) Sesbania (green manure) - Rice - Wheat
Ameliorating sodic lands in northern India requires a systematic cropping sequence that combines biological and chemical methods. The recommended rotation begins with Sesbania green manuring to add organic matter and organic acids. This is followed by rice, which tolerates ponding, and then wheat. This sequence progressively enhances soil permeability and facilitates the leaching of sodium.

22. (D) Precipitating calcium and magnesium, increasing sodicity
Irrigation water with a high residual sodium carbonate index contains excess bicarbonate and carbonate relative to calcium and magnesium. When applied to soil, these carbonate anions react with and precipitate soluble calcium and magnesium as insoluble carbonates. This precipitation increases the relative proportion of sodium ions in solution, thereby elevating the exchangeable sodium percentage and sodicity.

23. (B) The concentration of hydrogen ions in the soil solution
Soil acidity is categorized into active, exchangeable, and residual pools. Active acidity is the direct measure of hydrogen ions present in the soil solution at any given moment. This pool represents the immediate chemical environment experienced by plant roots and soil microorganisms, and it is the component directly measured by a standard soil pH meter.

NQDIA

24. (C) Coastal salinity is absent in the eastern states of India.
India possesses a diverse distribution of degraded soils across different geographic zones. While sodic soils dominate the Indo-Gangetic plains and acid soils occur in high-rainfall northeastern regions, coastal salinity is highly prevalent in the eastern coastal states, including West Bengal, Odisha, and Andhra Pradesh, due to marine inundation and high water tables.

25. (D) Non-exchangeable aluminum and hydrogen on clays and humus
Soil acidity comprises different pools that exist in a dynamic equilibrium. Residual acidity constitutes the largest pool of soil acidity and is not easily displaced by simple unbuffered salt solutions. This component is primarily made of non-exchangeable aluminum and hydrogen ions that are tightly bound to the crystalline structures of clay minerals and organic humus.

26. (A) Insoluble aluminum and iron phosphates
Phosphates are highly reactive anions whose availability in the soil solution is heavily dependent on pH. In highly acidic soils, large quantities of active aluminum and iron ions are solubilized. These trivalent cations rapidly react with soluble orthophosphate ions to form insoluble aluminum and iron phosphate precipitates, a chemical process commonly referred to as phosphorus fixation.

27. (B) It supplies both calcium and magnesium.
Liming materials are applied to neutralize soil acidity and improve nutrient availability. While calcitic limestone consists primarily of calcium carbonate, dolomitic limestone contains both calcium carbonate and magnesium carbonate. Consequently, using dolomitic limestone not

Under these chemical conditions, the abundance of exchangeable sodium causes extensive clay dispersion and aggregate breakdown. This structural collapse clogs pore spaces, resulting in a poorly structured soil characterized by highly restricted permeability.

46. (C) They form in high-rainfall regions due to the intense leaching of basic cations.
The genesis of acid soils is closely tied to climatic factors, specifically high precipitation. In areas experiencing heavy and frequent rainfall, water percolating through the soil profile intensively leaches basic cations like calcium, magnesium, and potassium. This depletion leaves the exchange complex dominated by hydrogen and aluminum ions, which naturally lowers the soil pH over time.

47. (D) Accumulation of sodium carbonates
Soil acidification is driven by processes that introduce hydrogen ions or remove basic cations. Key contributors include the nitrification of ammonium fertilizers, which releases hydrogen ions, the dissociation of organic acids from decomposing humus, and the hydrolysis of aluminum. Conversely, the accumulation of sodium carbonates increases soil pH and alkalinity, which directly opposes soil acidification.

48. (C) Excessive iron precipitation limiting availability
Plant growth in highly acidic soils is limited by several chemical constraints, including toxic levels of aluminum and manganese, along with severe deficiencies of calcium, magnesium, and phosphorus due to chemical fixation. However, iron solubility actually increases significantly under low pH conditions; thus, plant growth is never limited by excessive iron precipitation or reduced iron availability in acid soils.

49. (B) Both the active and exchangeable (reserve) acidity
Calculating the lime requirement of an acid soil is essential to determine the quantity of neutralizing material needed to reach a target pH. This calculation must account for both the active acidity present in the soil solution and the exchangeable acidity held on the clay and organic matter complexes, which acts as a buffer resisting pH changes.

50. (A) Both A and R are true and R is the correct explanation of A.
High concentrations of sodium in the soil solution severely restrict the plant uptake of other essential cations, particularly potassium. This inhibition occurs because sodium and potassium ions share similar hydrated ionic sizes and directly compete for the same selective carrier sites and transport channels across the root plasma membrane, leading to induced potassium deficiency under saline conditions.

51. (A) Stunted growth, dark green leaves, and reduced leaf expansion
Glycophytes are salt-sensitive plants that react immediately to elevated salinity in the soil profile. To minimize water loss and cope with osmotic stress, these plants restrict cellular expansion, leading to stunted shoot growth and reduced leaf area. The compaction of chlorophyll molecules within these smaller, unexpanded leaf cells typically results in a characteristic dark green foliage color.

52. (C) Expansion of electrical double layers on clays by hydrated sodium
Sodic soils are characterized by an abundance of exchangeable sodium on the clay colloid surfaces. Sodium possesses a low valency and a large hydrated ionic radius, which expands the electrical double layer surrounding individual clay particles. This expansion increases the electrostatic repulsion between the particles, causing clay dispersion and the subsequent breakdown of stable soil aggregates.

53. (A) It must be biologically oxidized by Thiobacillus to form sulfuric acid.
Elemental sulfur is an effective acidifying amendment used to reclaim calcareous sodic soils, but it is not immediately active upon application. It must first undergo biological oxidation by specialized soil bacteria, primarily Thiobacillus species. This microbial process converts elemental sulfur into sulfuric acid, which then reacts with native calcium carbonate to release soluble calcium for reclamation.

54. (D) Improving soil structure, porosity, and facilitating salt leaching
Incorporating farmyard manure into salt-affected soils plays a vital role in their physical and chemical reclamation. The organic matter from manure promotes the formation of stable

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of the depth of water that drains below the root zone to the total depth of irrigation water applied at the surface. Maintaining an adequate leaching fraction is essential to flush accumulated salts out of the soil.

37. (A) Nutrient deficiency exists that reduces yield without explicit visual symptoms.
Hidden hunger is a critical nutritional phenomenon in crops grown on degraded or nutrient-deficient soils. It describes a state where a plant suffers from a nutrient deficiency that is severe enough to restrict growth and reduce yield potential, yet does not produce any of the explicit, characteristic visual symptoms that would typically trigger corrective action.

38. (D) Interveinal chlorosis on the youngest leaves
In calcareous soils, high concentrations of calcium carbonate buffer the pH to alkaline levels, which drastically reduces iron solubility. Because iron is highly immobile within plant tissues, deficiency symptoms manifest first on the youngest, newly expanding leaves. This deficiency typically presents as a distinct interveinal chlorosis, where the veins remain green while interveinal areas turn yellow.

39. (B) Better drainage and lateral salt displacement away from seeds
Utilizing raised bed systems in salt-affected agricultural areas significantly alters hydrology and salt dynamics. When furrow irrigation is applied, water moves laterally and upward into the raised beds. This process displaces soluble salts away from the seed zone toward the center and top of the bed, while simultaneously improving aeration and drainage around the germinating seedlings.

40. (B) I, II and III
Establishing crops in saline soils requires integrated agronomic practices to overcome osmotic and toxic constraints. Pre-sowing seed priming with osmoprotectants accelerates germination, while raising the seed rate ensures adequate plant stand. Additionally, high-frequency irrigation with small water depths keeps the soil consistently moist, which dilutes the salt concentration in the soil solution and reduces osmotic stress.

NODIA

41. (D) Salt-tolerant varieties for saline and sodic soils
The KRL series of wheat, developed by the Central Soil Salinity Research Institute, represents a critical genetic resource for salt-affected agricultural zones. These specific cultivars are physiologically adapted to withstand high concentrations of soluble salts and exchangeable sodium, allowing farmers to obtain sustainable grain yields in both saline and sodic soil environments across northern India.

42. (A) Tolerate high levels of soluble aluminum and manganese
Acid soils pose severe chemical challenges to crops, primarily through toxic levels of soluble aluminum and manganese. While many crops fail under these conditions, acid-tolerant species like oats and potatoes are capable of yielding well. These plants possess internal and external physiological mechanisms that allow them to tolerate high concentrations of these toxic metals within their tissues.

43. (B) Acid root exudates and biomass decomposition lower soil pH and improve structure.
Incorporating Sesbania within crop rotations is a cornerstone of biological reclamation for sodic lands. During growth, its roots release acidic exudates that help dissolve native calcium carbonate. Upon incorporation, the decomposition of its organic biomass releases carbon dioxide and organic acids, which further lower the soil pH, improve permeability, and assist in displacing exchangeable sodium.

44. (B) Requires careful EC monitoring of blended water to prevent soil salinization.
Conjunctive water management involves blending fresh canal water with saline groundwater to expand irrigation capacity. However, a primary disadvantage of this practice is that it requires rigorous and continuous monitoring of the blended water's electrical conductivity. Without precise management, applying water with excessive salt concentrations will gradually induce soil salinization and damage the crop root zone.

45. (A) Poorly structured with restricted soil permeability
A soil with a high pH, low electrical conductivity, and an exchangeable sodium percentage exceeding fifteen is classified as a classic sodic soil.

bypassing soil fixation and ensuring immediate uptake.

82. (D) Wheat
Organic soils and degraded peatlands often exhibit low plant availability of copper due to strong chemical binding by organic compounds. Under these conditions, identifying copper deficiency early is crucial for maintaining crop productivity. Wheat is widely recognized as a highly sensitive indicator crop that shows early and distinct visual symptoms of copper deficiency, such as leaf-tip spiraling.

83. (A) Salts migrate to the bed top, letting seeds planted on shoulders avoid salinity.
The raised bed planting system with furrow irrigation is specifically designed to manage salinity during crop establishment. As irrigation water moves laterally and upward into the bed via capillary action, it carries soluble salts with it. These salts accumulate at the top of the bed, allowing seeds planted on the shoulders to germinate in a low-salt environment.

84. (C) Water deficit at imbibition due to low osmotic potential
Reduced germination percentages in saline soils are primarily driven by physical water limitations. High concentrations of dissolved salts in the surrounding soil solution lower its osmotic potential. This osmotic barrier restricts the gradient necessary for the seed to absorb water during the critical imbibition phase, thereby delaying or completely preventing the metabolic processes required for germination.

85. (A) Inability to exclude sodium at the root surface
Highly salt-tolerant crop varieties utilize several key physiological traits to survive saline conditions. These include a strong capacity to compartmentalize sodium within vacuoles, maintaining high tissue potassium-to-sodium ratios, and synthesizing compatible organic solutes for osmotic adjustment. Conversely, an inability to exclude sodium at the root surface is a characteristic of sensitive species, not tolerant ones.

86. (D) Potato
Acidic soils pose significant chemical challenges, particularly through toxic concentrations of soluble aluminum. Potato is an acid-tolerant crop that can produce viable yields under moderately low pH conditions. However, it is highly responsive to tailored liming practices that neutralize toxic exchangeable aluminum in the root zone while maintaining a slightly acidic pH, which helps prevent diseases like common scab.

87. (B) Open up dense subsoil layers and improve water permeability
Including deep-rooted crop species within rotations designed for reclaiming degraded and salt-affected soils offers significant structural benefits. The extensive root systems of these crops penetrate dense subsoil horizons, creating physical macropores and biopores as they decay. This biological drilling opens up the soil profile, which substantially improves water infiltration, root aeration, and deep leaching.

88. (C) Exchangeable sodium percentage
Irrigating crops with water characterized by a high residual sodium carbonate index poses long-term hazards to soil chemistry. The excess bicarbonate and carbonate ions in the water precipitate soluble calcium and magnesium as insoluble carbonates. This precipitation increases the relative proportion of sodium on the soil exchange complex, leading to a progressive rise in the exchangeable sodium percentage.

89. (D) Better physical structure and water permeability
Saline and sodic soils differ significantly in their physical and chemical properties. While sodic soils suffer from clay dispersion and aggregate breakdown due to high exchangeable sodium, saline soils contain high concentrations of soluble salts that act as flocculating agents. Consequently, saline soils generally exhibit a much better physical structure, superior aggregate stability, and higher water permeability.

90. (A) Both A and R are true and R is the correct explanation of A.
Applying agricultural lime to highly alkaline sodic soils is highly ineffective for chemical reclamation. This inefficiency occurs because calcium carbonate is practically insoluble at soil pH values exceeding eight point five. As a result, the lime fails to dissolve and supply the soluble calcium ions needed to displace exchangeable sodium from the clay colloid complex.

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soil aggregates, which increases total porosity and hydraulic conductivity. This structural improvement enhances water infiltration, which directly facilitates the downward leaching of accumulated soluble salts and sodium out of the root zone.

55. (B) Chemical reduction of sulfates to toxic hydrogen sulfide
Waterlogging triggers a rapid depletion of oxygen, causing the soil redox potential to drop sharply from oxidized to highly reduced levels. When the redox potential falls below negative two hundred millivolts, anaerobic microorganisms utilize sulfate as a terminal electron acceptor. This biochemical reduction pathway converts sulfates into hydrogen sulfide, a volatile compound that is highly toxic to plant roots.

56. (C) Metabolic adaptations to avoid toxic ethanol build-up
Hypoxia-tolerant crops possess specialized metabolic adaptations that allow them to survive prolonged periods of waterlogging and anoxia. Under anaerobic conditions, these plants shift from aerobic respiration to alcoholic fermentation. To prevent the toxic accumulation of ethanol within their tissues, adapted crops upregulate alternative pathways, such as malate accumulation, or efficiently transport and excrete metabolic byproducts from root cells.

57. (D) Safely and rapidly remove excess ponded water from soil surfaces
Surface drainage systems are designed to manage water logging in agricultural fields by addressing excess surface water. The primary functional goal of these systems is to safely and rapidly remove ponded surface runoff resulting from intense rainfall or over-irrigation. By preventing prolonged surface ponding, these systems protect crops from immediate oxygen depletion in the upper soil profile.

58. (A) The leaching requirement decreases as the irrigation water salinity increases.
Hydrological management of saline soils is based on maintaining a favorable salt balance within the crop root zone. An increase in the salinity of the irrigation water means that more salt is being introduced to the soil. Consequently, a larger volume of water must pass through the profile, meaning the leaching requirement actually increases rather than decreases under these conditions.

59. (B) Reduced solubility and availability of zinc at high soil pH levels
Sodic soils are characterized by alkaline pH levels, which severely affect the solubility of essential micronutrients. Zinc is highly sensitive to pH variations; its solubility decreases a hundredfold for every single unit increase in soil pH. Therefore, the widespread zinc deficiency observed in sodic soils is primarily caused by this chemically induced reduction in solubility and availability.

60. (D) P-3, Q-2, R-1, S-4
Visual diagnostic symptoms correspond directly to specific soil stresses. Marginal necrosis on older leaves occurs from salinity-induced chloride accumulation. Interveinal chlorosis on young leaves indicates iron immobility in alkaline calcareous sodic soils. Stunted, brown roots reflect aluminum toxicity in highly acidic soils. Finally, a general bronzing of older leaves is a classic symptom of iron toxicity in waterlogged soils.

61. (A) Moist soil profiles dilute osmotic concentration of the soil solution.
High-frequency irrigation with small depths of water is highly beneficial in saline soils. Keeping the soil profile consistently moist prevents the soil solution from drying out and concentrating. This consistent moisture dilutes the concentration of dissolved salts, thereby maintaining a higher osmotic potential in the root zone and making it easier for crops to absorb water.

62. (C) It triggers pre-germinative metabolic steps, ensuring faster, uniform emergence.
Seed priming with osmoprotectants is an effective pre-sowing treatment for crops grown in saline environments. This process involves hydrating the seeds enough to initiate early, pre-germinative metabolic activities without allowing radicle emergence. When these primed seeds are sown, they germinate much faster and more uniformly, which helps them overcome the osmotic and toxic barriers of saline soils.

63. (D) Selective potassium uptake and compartmentalization of sodium in older leaves
The CSR series of rice varieties utilizes specialized physiological mechanisms to tolerate

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species. Under aerobic conditions, reduced ferrous iron is oxidized to ferric iron, and reduced manganese is converted to its tetravalent form. Similarly, reduced hydrogen sulfide is oxidized to sulfate, while reduced ammonium undergoes nitrification to form nitrate, reflecting the thermodynamic stability of these elements in oxygenated environments.

101. (A) Rapid loss of nitrogen through denitrification to N_2 and N_2O
Applying nitrogen fertilizer to waterlogged soils requires careful selection of the chemical form. In highly reduced, flooded environments, anaerobic microflora utilize nitrate as an alternative electron acceptor. Consequently, applying nitrate-based fertilizers rather than ammonium-based forms leads to rapid nitrogen loss through denitrification, converting valuable nitrate into gaseous nitrogen and nitrous oxide, which escape into the atmosphere.

102. (D) Rapid internode elongation keeping foliage above water
Deepwater rice varieties have evolved specialized morphological adaptations to survive prolonged, deep submergence. When water levels rise, these plants initiate rapid internode elongation, driven by hormonal signals like ethylene and gibberellin. This accelerated upward growth allows the crop to keep its upper foliage and photosynthetic machinery above the water surface, ensuring oxygen uptake and survival.

103. (B) Preventing upward capillary salt movement from shallow water tables
Managing agricultural drainage is critical for preventing waterlogging and soil salinization. While surface drainage is designed to handle excess surface runoff, subsurface drainage is uniquely effective at controlling groundwater levels. By lowering the shallow water table, subsurface systems disrupt the continuous capillary rise of saline water to the surface, thereby protecting the root zone from salt accumulation.

104. (C) EC of irrigation water to the target EC of drainage water
The leaching requirement represents the fraction of applied irrigation water that must pass through the root zone to prevent salinity build-up. In its simplest mathematical formulation, the leaching requirement is calculated as the ratio of the electrical conductivity of the incoming irrigation water to the maximum permissible electrical conductivity of the draining water below the root zone.

105. (D) Tobacco
Nutrient imbalances and specific ion accumulation in degraded soils can severely degrade the quality of harvested crop products. For instance, high concentrations of chloride ions in the soil solution lead to excessive uptake by crops. In tobacco cultivation, this luxury consumption of chloride is highly detrimental, as it directly reduces the burning quality and leaf usability.

106. (B) Iron
Waterlogged conditions reduce insoluble ferric iron to soluble ferrous iron, which rice plants absorb in excessive amounts. This toxic accumulation of ferrous iron causes physiological stress, manifesting visually as a distinct brown or bronze discoloration on the leaves. This characteristic nutritional disorder is widely recognized as bronzing and primarily affects lowland rice grown in poorly drained soils.

NODIA

107. (A) Deep inversion plowing
Deep inversion plowing physically turns over the soil profile, which relocates accumulated salts from the deeper subsoil layers directly up to the surface root zone. In salt-affected areas, minimizing or completely eliminating this practice is crucial to prevent capillary action from exacerbating surface salinity, thereby protecting young seedlings and maintaining overall crop productivity.

108. (C) It may exacerbate waterlogging and subsequent hypoxia.
In poorly drained environments, applying irrigation water at a high frequency prevents the soil from drying out, which leads to a saturated root zone. This continuous saturation restricts crucial oxygen exchange between the soil pores and the atmosphere, severely exacerbating waterlogging issues and inducing root hypoxia, which ultimately impairs respiration and nutrient uptake.

109. (D) Selectively exclude sodium and absorb potassium at the root interface
The KRL wheat series possesses specialized physiological mechanisms that enable the root system to selectively restrict the uptake of

toxicity manifest first as necrosis along leaf margins.

73. (D) Barley
Crops vary widely in their physiological capacity to tolerate soluble salts in the root zone. While beans and apples are highly sensitive to salinity, and corn is classified as moderately sensitive, barley is recognized globally as a highly salt-tolerant field crop. It can maintain high relative yields and complete its life cycle under elevated electrical conductivity conditions.

74. (A) Dispersed clay particles clog macropores, forming an impermeable matrix.
Sodic soils suffer from extremely poor aeration and restricted water movement. This physical degradation is chemically driven by high exchangeable sodium, which causes clay particles to disperse and expand. These individual dispersed clay micelles migrate through the soil profile and physically clog the conducting macropores, creating a dense, impermeable soil matrix that restricts the diffusion of oxygen.

75. (B) Presence of native soil lime to react with the produced sulfuric acid
Utilizing iron pyrites for reclaiming sodic soils relies on chemical transformations. Unlike gypsum, which is directly soluble, pyrites must be oxidized by soil microbes to form sulfuric acid. This acid must then react with native soil lime to dissolve and release soluble calcium. Therefore, the reclamation efficiency of pyrites is heavily dependent on having adequate native soil carbonate.

76. (B) Biogenic CO_2 and organic acids help dissolve $CaCO_3$ to replace exchangeable Na^+.
Incorporating green manure into sodic soils is a highly effective reclamation practice. The microbial decomposition of this organic biomass releases significant amounts of biogenic carbon dioxide and organic acids into the soil. These compounds lower the localized soil pH and dissolve insoluble native calcium carbonate, releasing soluble calcium ions that displace exchangeable sodium from the clay exchange sites.

77. (A) Fe^{3+} to Fe^{2+}
Waterlogging restricts the diffusion of atmospheric oxygen into the soil, forcing anaerobic microorganisms to use alternative electron acceptors for respiration. After oxygen, nitrate, and manganese are depleted, microbes reduce insoluble ferric iron to soluble ferrous iron. This chemical reduction process represents a transition from the trivalent oxidized form to the divalent reduced state within the soil profile.

78. (C) Formation of continuous interconnected gas spaces (aerenchyma) in tissues
Wetland rice exhibits highly specialized morphological adaptations that allow them to thrive in flooded, anaerobic soils. The most critical adaptation is the development of aerenchyma, which consists of continuous, interconnected gas-filled spaces within the plant tissues. These specialized cellular pathways facilitate the downward diffusion of oxygen from the atmosphere down to the root system, sustaining aerobic respiration.

79. (D) The high initial capital cost of installation and maintenance.
Subsurface tile drainage is highly effective at managing high water tables and root-zone salinity, but it possesses distinct drawbacks compared to surface drainage. The primary disadvantage of installing a subsurface system is the exceptionally high initial capital investment required for engineering, trenching, purchasing perforated pipes, and the ongoing maintenance costs associated with preventing pipe clogging over time.

80. (D) III only
Successful leaching of saline soils requires specific hydrological conditions, including using water of lower salinity than the soil solution and having functional subsurface drainage to export dissolved salts below the root zone. However, having evaporation exceed infiltration is highly undesirable during reclamation, as high evaporation draws salts back up to the soil surface via capillary action.

81. (B) Routine soil testing and targeted foliar spray of deficient micronutrients
Hidden hunger occurs when crops suffer from nutrient deficiencies that reduce yield without showing visible symptoms. To eliminate this issue in degraded soils, farmers must implement proactive management strategies. The most effective approach combines routine soil and tissue testing to identify early-stage deficits with targeted foliar applications of key micronutrients,

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high salinity and sodicity. These plants maintain a high potassium-to-sodium ratio in active tissues by selectively absorbing potassium over sodium at the root interface. Additionally, they transport and compartmentalize excess toxic sodium ions into older, senescing leaves, thereby protecting the young, photosynthetically active foliage.

64. (C) Precipitation of aluminum internally as aluminum carbonate crystals
Acid-tolerant crop varieties employ several physiological strategies to cope with toxic aluminum levels. These include secreting organic acids like citrate from root tips to chelate aluminum externally, and raising rhizosphere pH to decrease aluminum solubility. However, plants do not precipitate aluminum internally as aluminum carbonate crystals, as carbonates are highly unstable and virtually non-existent under acidic soil conditions.

65. (B) Biomass producing carbonic acid upon decay, aiding gypsum dissolution
Integrating summer green manure crops like Sesbania into a rice-wheat rotation is highly effective for reclaiming sodic soils. Upon incorporation, the rapid microbial decomposition of this organic biomass releases significant quantities of carbon dioxide. This carbon dioxide reacts with soil water to form carbonic acid, which lowers the pH and directly accelerates the dissolution of applied gypsum.

66. (D) Dilute bicarbonate levels to prevent soil structure degradation
Conjunctive use of high residual sodium carbonate water and fresh canal water is an important management strategy. Blending these two water sources aims to dilute the concentration of carbonate and bicarbonate anions. This dilution reduces the precipitation of soluble calcium and magnesium, thereby preventing an increase in exchangeable sodium and safeguarding the physical structure of the soil.

67. (A) Sodic soil : $EC_e > 4$ dS/m
Under the standard classification of salt-affected soils, sodic soils are characterized by an exchangeable sodium percentage greater than fifteen and a high soil pH typically exceeding eight point five. Because these soils do not contain excessive amounts of soluble salts, their electrical conductivity remains below four decisiemens per meter, making the pairing with a high conductivity value incorrect.

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68. (C) Gujarat
India features a significant area of salt-affected lands distributed across several states. According to national soil databases, the state of Gujarat holds the largest geographic area of salt-affected soils in the country. This high prevalence is due to its extensive coastline, arid to semi-arid climatic conditions, and widespread groundwater salinity in its low-lying plains.

69. (A) Structural aluminum in internal clay lattices
Active acidity represents the concentration of free hydrogen ions present in the soil solution, which directly determines the measured soil pH. While dissolved carbon dioxide, dissociated organic acids, and exchangeable hydrogen ions contribute directly to the active acidity pool in water, structural aluminum held within the internal crystalline lattices of clay minerals is non-reactive and does not participate.

70. (A) I only
Soil acidity significantly alters the availability of essential plant nutrients and biological activity. Under highly acidic conditions, legume nodulation is severely suppressed due to restricted survival of Rhizobium bacteria, and deficiencies of calcium and magnesium are highly common. However, molybdenum availability decreases rather than increases at low pH, making the assertion of its increased availability incorrect.

71. (B) Pure calcium carbonate
The neutralizing value of a liming material, also known as its calcium carbonate equivalent, represents its acid-neutralizing capacity. This value is quantitatively expressed relative to pure calcium carbonate, which is assigned an arbitrary standard value of one hundred percent. All other liming materials are compared to this standard based on their molecular weights and neutralizing efficiency.

72. (C) Margins and tips of older leaves
Boron toxicity is a common issue in arid and saline soils where boron accumulates to toxic levels in the soil solution. Because boron is transported through the transpiration stream and is relatively immobile once deposited, it tends to accumulate at the ends of the vascular system. Consequently, visual symptoms of

91. (B) ≈ 6.7 million hectares
Salt-affected soils represent a major category of degraded agricultural land in India, limiting crop production across various agro-ecological zones. National estimates compiled by soil salinity research organizations indicate that approximately six point seven million hectares of land are currently affected by salinity and sodicity combined, requiring systematic reclamation and management strategies to restore agricultural productivity.

92. (B) A pH meter in a soil-water suspension
Soil acidity is divided into active, exchangeable, and residual fractions based on how the hydrogen ions are held. Active acidity represents the concentration of hydrogen ions present directly in the soil solution. This specific pool is measured operationally using a calibrated pH meter in a standardized soil-to-water suspension, reflecting the immediate chemical environment of the plant roots.

93. (A) Aluminum binds to cell wall pectins and disrupts root apical meristem activity.
Aluminum toxicity is a primary factor limiting crop growth in highly acidic soils. Trivalent aluminum ions are highly reactive and bind strongly to negatively charged pectins within the cell walls of root tips. This binding increases cell wall rigidity and directly disrupts the division and elongation of cells in the root apical meristem, halting root development.

94. (C) It is determined solely by measuring active acidity in water.
Calculating the lime requirement of an acid soil is a multi-faceted process. It must account for the buffering capacity of the clay system, the target pH of the crop, and the neutralizing value of the liming agent. Consequently, the lime requirement cannot be determined solely by measuring the active acidity in water, as this ignores the larger exchangeable acidity pool.

95. (D) Applying supplemental potassium mitigates toxic effects of high sodium.
Under salinity stress, high concentrations of sodium in the soil solution competitively inhibit the uptake of other essential plant nutrients. Because sodium and potassium compete for similar transport pathways on root membranes, applying supplemental potassium increases its concentration relative to sodium. This practice enhances selective potassium uptake, maintaining a favorable internal ionic balance and mitigating sodium toxicity.

96. (C) It ignores environmental variables like humidity affecting transpiration and salt uptake.
The relative yield decrement model is a standard framework used to classify crop salt tolerance, but it possesses limitations. A major disadvantage of this model is that it evaluates tolerance under controlled conditions, thereby ignoring environmental variables such as relative humidity and temperature. These climatic factors significantly influence plant transpiration rates, which directly affect water and salt uptake.

97. (B) Clay swelling and dispersion block conducting soil pores.
Sodic soils are characterized by a high percentage of exchangeable sodium on clay surfaces. Due to sodium's large hydrated size and low charge, it expands the electrical double layer around clay particles. This expansion forces clay micelles to swell and disperse. These dispersed particles then migrate and physically block the conducting soil pores, severely reducing hydraulic conductivity.

98. (D) Generate acid to dissolve native soil lime
Chemical amendments used to reclaim sodic soils are classified into two primary categories based on their mode of action. The first group comprises amendments like gypsum that supply soluble calcium directly to displace exchangeable sodium. The second group consists of acidifying materials, such as sulfur and pyrites, which generate acid to dissolve native, insoluble soil calcium carbonate.

99. (A) The efficiency of gypsum is enhanced through improved infiltration and biological activity.
Applying farmyard manure during the chemical reclamation of sodic soils provides significant synergistic benefits. The addition of organic matter improves soil aggregation, which enhances water infiltration and structural stability. This physical improvement facilitates the downward movement of water, thereby increasing the efficiency of applied gypsum by accelerating the leaching of displaced exchangeable sodium out of the root zone.

100. (B) P-3, Q-4, R-1, S-2
Soil redox reactions involve chemical transformations between reduced and oxidized

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only neutralizes active hydrogen ions but also simultaneously supplies both calcium and magnesium, addressing multiple nutrient deficiencies common in acid soils.

28. (B) Toxicity stems from internal accumulation of Na^+ and Cl^- ions, while osmotic stress restricts root water uptake.
Salinity impacts crop growth through two distinct physiological phases. Osmotic stress is an immediate, external effect occurring in the soil solution, where high salt concentrations restrict the root's ability to absorb water. Conversely, specific ion toxicity is a slower, internal process caused by the excessive accumulation of sodium and chloride ions within plant tissues, disrupting metabolism.

29. (A) It is moderately sensitive to moderately tolerant.
Crop salt tolerance is quantitatively assessed by measuring the electrical conductivity of the saturated soil extract at which yield decreases. A crop that exhibits a fifty percent yield reduction at an electrical conductivity of six decisiemens per meter is categorized as moderately sensitive to moderately tolerant, as highly sensitive crops suffer equivalent damage at much lower salinity thresholds.

30. (C) I and II
High sodicity deteriorates soil physical properties due to the dispersing effect of exchangeable sodium on clay particles. This dispersion leads to the breakdown of stable soil aggregates, resulting in reduced hydraulic conductivity and surface crusting that hinders seedling emergence. Rather than increasing, macroporosity is severely reduced, which restricts aeration and root development.

31. (D) The difference between the initial and target soil ESP
Gypsum is the most widely utilized chemical amendment for reclaiming sodic soils. The exact quantity of agricultural grade gypsum required is calculated based on the gypsum requirement of the soil. This determination is directly proportional to the difference between the initial exchangeable sodium percentage and the desired target exchangeable sodium percentage of the soil profile.

32. (C) Production of organic acids that mobilize native calcium carbonate
Press mud is a valuable organic byproduct of the sugar industry used for reclaiming sodic soils. Upon incorporation into the soil, its decomposition by microbes releases significant quantities of carbon dioxide and organic acids. These acidic compounds lower the micro-environmental pH and dissolve insoluble, native calcium carbonate, thereby releasing soluble calcium to displace exchangeable sodium.

33. (B) Oxygen $\rightarrow$ Nitrate $\rightarrow$ Manganese $\rightarrow$ Iron $\rightarrow$ Sulfate
Upon waterlogging, soil microbes rapidly consume dissolved oxygen, initiating anaerobic respiration. As the soil becomes progressively reduced, microorganisms utilize alternative electron acceptors in a highly predictable thermodynamic sequence. This biochemical pathway proceeds from oxygen reduction to nitrate, followed by the reduction of manganese oxides, ferric iron, and eventually sulfate to sulfide under extreme anoxia.

34. (D) Enhanced oxygen capture near the surface water
Flooding induces severe oxygen deficiency in the rhizosphere, which restricts normal root respiration. In response, waterlogging-tolerant crops develop adventitious roots near the soil surface or water-air interface. This morphological adaptation maximizes the capture of dissolved oxygen from the surface water, helping the plant sustain aerobic metabolism despite the anaerobic conditions in the underlying soil profile.

35. (A) Subsurface drainage manages water table and salinity levels in root zones.
Drainage systems are critical for reclaiming waterlogged and saline agricultural lands. While surface drainage is designed to remove ponded surface water rapidly, subsurface drainage specifically lowers and maintains the shallow water table. This action facilitates the downward leaching of salts out of the active root zone, preventing capillary rise and secondary salinization.

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36. (C) The ratio of drainage water depth to applied irrigation water depth.
The leaching fraction is a fundamental hydrological concept used to manage root-zone salinity. It is quantitatively defined as the ratio

harmful sodium ions while actively absorbing essential potassium ions from the soil solution. This selective exclusion maintains a favorable potassium-to-sodium ratio within the plant tissue, protecting enzymatic processes and cellular functions from sodium toxicity.

110. (C) II and III
Oats exhibit strong physiological tolerance to aluminum, allowing growth in highly acidic soils where active aluminum is prevalent. Meanwhile, potatoes benefit from mildly acidic soil conditions, which naturally suppress the development of Streptomyces scabies, the pathogen responsible for potato scab disease. Conversely, tea plants require acidic, not basic, soils for optimal growth.

111. (B) Rice cultivation involves puddling and ponding, facilitating sodium leaching.
Cultivating rice involves continuous water ponding and soil puddling, which significantly increases water movement through the soil profile. This flushing action dissolves soluble sodium complexes and leaches them down below the active root zone. This biological and physical mechanism makes the rice-wheat rotation highly effective in gradually reclaiming and improving sodic agricultural lands.

112. (D) Applying excess water over the crop requirement to ensure effective salt leaching
Irrigating with high-salinity brackish water continually adds soluble salts to the topsoil. To prevent these salts from accumulating to toxic levels in the root zone, management must incorporate an extra volume of water beyond normal crop requirements. This excess application, known as the leaching fraction, washes accumulated salts down past the root zone.

113. (A) Saline
Soil classification parameters dictate that saline soils possess an electrical conductivity of the saturated extract greater than four decisiemens per meter, a pH value below eight point five, and an exchangeable sodium percentage below fifteen. Because these specific analytical values fall precisely within these boundaries, the soil is categorized under the saline classification.

114. (C) Acid soils are concentrated in high-rainfall states due to intense leaching of basic cations.
In regions characterized by high annual rainfall, the persistent downward movement of water causes intense leaching of basic cations, such as calcium, magnesium, and potassium, from the soil exchange complex. These basic elements are replaced by hydrogen and aluminum, resulting in the concentration and formation of highly acidic soils in wet geographical areas.

115. (A) Aluminum and hydrogen ions bound on the cation exchange complex
Reserve acidity, also known as exchangeable acidity, is constituted by hydrogen and aluminum ions that are electrostatically bound to the surfaces of clay particles and organic matter complexes. These bound ions are in equilibrium with the active soil solution, acting as a massive buffer that replenishes active acidity when soluble hydrogen is neutralized.

116. (D) Calcium deficiency causes necrotic, gelatinous root tips that die back; aluminum toxicity causes stubby, swollen, and severely thickened roots.
In acidic soils, calcium deficiency impairs cell wall integrity, causing root tips to become gelatinous, blackened, and die back. Conversely, aluminum toxicity directly inhibits cell division and elongation at the root apex, forcing roots to become stubby, swollen, and thick, which severely limits their capacity to explore the soil for water and nutrients.

117. (B) Pure calcium oxide (CaO) has a neutralizing value greater than 100% relative to pure calcium carbonate.
The neutralizing value of liming materials is calculated relative to pure calcium carbonate, which is assigned a baseline value of one hundred percent. Because calcium oxide has a lower molecular weight than calcium carbonate, a given mass of calcium oxide contains more neutralizing equivalents, resulting in a neutralizing value significantly greater than one hundred percent.

118. (C) It diverts metabolic energy and carbon resources to synthesize compatible solutes.
Synthesizing organic osmolytes like proline, glycine betaine, and soluble sugars for osmotic adjustment requires substantial metabolic energy and carbon skeletons. This metabolic diversion significantly reduces the allocation of carbon resources toward active vegetative

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138. (B) Buffer pH or exchangeable acidity of the soil
Calculating the precise agricultural lime requirement requires measuring the soil's buffer pH or exchangeable acidity. This parameter accounts for both active acidity in the soil solution and reserve acidity held on the cation exchange complex. This ensures that sufficient lime is applied to neutralize both fractions and reach the desired target soil pH.

139. (A) Induced deficiency of K+ and Ca2+ due to high Na+ concentrations.
Under severe saline conditions, excessive concentrations of sodium ions in the soil solution compete directly with potassium and calcium ions for binding sites on root transporter proteins. This competitive inhibition prevents the plant from absorbing adequate amounts of these essential macronutrients, leading to induced deficiencies of potassium and calcium.

140. (C) P-1, Q-2, R-3, S-4
Crops exhibit distinct physiological limits regarding soil salinity. Cotton is classified as a tolerant crop, wheat is moderately tolerant, and groundnut is highly sensitive with a low salinity threshold. In contrast, the date palm is highly tolerant, possessing specialized mechanisms that allow it to grow productively in soils with elevated salt concentrations.

141. (D) Using a divalent cation like calcium to displace exchangeable sodium.
Sodium is a monovalent cation with a large hydrated radius, which causes clay dispersion. Replacing exchangeable sodium on the clay complex requires introducing a divalent cation like calcium, which has a stronger affinity for exchangeable sites. This chemical displacement allows the released sodium to be leached out of the soil profile.

142. (C) Gypsum supplies calcium directly; sulfur requires oxidation to dissolve native calcium.
Gypsum is a direct source of soluble calcium that dissolves directly in soil water. Conversely, elemental sulfur must first be biologically oxidized by soil bacteria to form sulfuric acid. This acid then reacts with native, insoluble calcium carbonate in calcareous soils, dissolving it to release the soluble calcium needed for sodium displacement.

143. (B) It improves aggregation, increases infiltration, and releases pH-lowering organic acids.
Applying farmyard manure improves the physical structure of sodic soils by promoting particle aggregation, which enhances water infiltration and aeration. Additionally, the decomposition of manure releases organic acids and carbon dioxide, which lower the high soil pH and assist in dissolving native calcium carbonate to facilitate sodium exchange.

144. (D) All soil pores are filled with water, restricting gas exchange with the atmosphere.
Waterlogging occurs when a soil's pore spaces become completely saturated with water, displacing gaseous oxygen. This physical saturation creates a barrier that severely restricts the diffusion of oxygen from the atmosphere into the soil. As a result, the root zone becomes anaerobic, hindering normal plant respiration and nutrient uptake.

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145. (A) Ethanolic fermentation
When soil flooding depletes oxygen, plants can no longer perform aerobic respiration. To survive anoxia, tolerant plants switch their metabolism to anaerobic pathways, primarily ethanolic fermentation. This biochemical pathway regenerates NAD^+ from $NADH$, allowing glycolysis to continue and producing a small amount of adenosine triphosphate to sustain vital cellular survival processes.

146. (C) Soil hydraulic conductivity and depth to the impermeable layer.
The design of subsurface tile drainage systems relies on calculating the proper distance between parallel drains. This spacing is determined by the soil's hydraulic conductivity, which governs how fast water flows through the soil pores, and the depth to the underlying impermeable layer, which establishes boundary conditions for water movement.

147. (A) Changes in soil salt storage over time
Under steady-state conditions, water and salt inputs are assumed to equal outputs over a given time interval. Because salt levels within the soil profile remain in a constant dynamic equilibrium, any temporary changes in soil salt storage are eliminated from the calculation of the simple leaching fraction model.

sensitivity, they exhibit recognizable and distinct visual symptoms of stress far earlier than other crops. Farmers utilize these diagnostic plants as early warning systems to implement corrective soil or nutrient management strategies.

129. (A) Furrow planting : Ensure seeds are placed in the zone of highest salinity
In salt-affected soils, planting configuration is designed to minimize salinity stress on germinating seeds. Furrows and ridge tops are areas where salts accumulate heavily due to evaporation. Placing seeds directly in the zone of highest salinity is incorrect, as agronomic practices aim to position seeds where salt concentrations are minimized, such as the mid-slope.

130. (C) A is true but R is false.
Priming seeds with potassium nitrate solutions significantly enhances germination rate, enzymatic activity, and seedling vigor, which improves crop establishment under saline conditions. However, potassium nitrate does not chemically neutralize or eliminate toxic sodium ions from the bulk soil; instead, it biologically enhances the plant's internal potassium status and osmotic tolerance mechanisms.

131. (A) Sustaining growth and yield under salinity and alkalinity stresses
The CSR rice varieties, developed in India, are specifically bred and genetically tailored to withstand severe soil salinity and sodicity. These cultivars exhibit robust physiological adaptations, such as efficient sodium exclusion and superior osmotic adjustment, allowing them to sustain high vegetative growth and grain yields in highly alkaline and salt-affected lands.

132. (D) Alternating deep-rooted tolerant crops with green manures to reduce soil ESP.
Rotating deep-rooted, salt-tolerant crops with organic green manures enhances biological reclamation. The deep root systems physically break up dense soil layers, improving permeability, while green manures add rich organic matter that decomposes to release carbon dioxide and organic acids. This process dissolves native calcium, helping displace exchangeable sodium and reducing the exchangeable sodium percentage.

133. (B) Precipitating calcium as calcium carbonate, raising the soil ESP.
Irrigation water with high residual sodium carbonate contains excessive carbonate and bicarbonate ions, which react with soluble soil calcium, precipitating it as insoluble calcium carbonate. This loss of soluble calcium allows sodium ions to dominate the clay exchange complex, which drastically increases the exchangeable sodium percentage and degrades soil structure.

134. (C) It cannot differentiate between the specific ions contributing to salinity.
While measuring the electrical conductivity of a saturated soil extract provides a rapid assessment of total soluble salt concentrations, it does not distinguish between individual ionic species such as sodium, chloride, sulfate, or calcium. Consequently, supplementary chemical analyses are necessary to identify specific toxic ions and determine precise reclamation strategies.

135. (D) Salinization driven by capillary rise from a shallow, saline water table.
In inland semi-arid regions, high evaporative demand exceeds precipitation. When the water table is shallow and saline, water moves upward through the soil profile via capillary action. As this water evaporates at the surface, it leaves behind dissolved salts, leading to progressive salinization and the formation of saline soils.

136. (A) Weathering of limestone parent material
Limestone consists primarily of calcium carbonate, which is a basic compound. Weathering of limestone releases calcium and carbonate ions, which consume hydrogen ions and raise soil pH. Therefore, this process serves as a major mechanism of neutralizing acidity rather than acting as a source of hydrogen ions in soil.

137. (B) Failure of terminal bud development and cell wall collapse in expanding tissues.
Calcium is a crucial structural component of plant cell walls, specifically within the middle lamella. Severe calcium deficiency in highly acidic soils restricts cell division and weakens cell wall stability. This structural failure causes the collapse of rapidly expanding apical tissues and halts terminal bud development, leading to distorted, necrotic growing tips.

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158. (C) In acid soils, P is fixed by Fe/Al oxides; in calcareous soils, as Ca phosphates.
In acidic soils, soluble phosphorus is fixed through precipitation and adsorption reactions with active iron and aluminum oxides, forming highly insoluble compounds. In contrast, in calcareous alkaline soils, phosphorus reacts with abundant calcium ions, precipitating as various forms of calcium phosphate, which limits its availability to growing crops.

159. (B) (Exchangeable Sodium / Cation Exchange Capacity) x 100
The exchangeable sodium percentage is a chemical ratio that represents the proportion of a soil's cation exchange capacity occupied by sodium ions. It is calculated by dividing the quantity of exchangeable sodium by the total cation exchange capacity, then multiplying by one hundred, serving as a key diagnostic criterion for sodic soils.

160. (D) Experiences rapid, severe yield drops with small salinity increases above the threshold.
In relative yield models, the slope parameter represents the rate of yield decline per unit increase in salinity above the threshold level. A very steep slope indicates that the crop is highly sensitive to salinity increases beyond its threshold, experiencing rapid and severe yield losses with only minor increases in soil salt concentration.

161. (A) The electrical conductivity of sodic soils is always above 4 dS/m.
Sodic soils are characterized by an exchangeable sodium percentage greater than fifteen, a high pH typically exceeding eight point five, and low soluble salt concentrations. Consequently, their electrical conductivity is generally below four decisiemens per meter. Stating that their electrical conductivity is always above this threshold is incorrect, as that describes saline soils.

162. (C) Coastal soils have high permeability and the issue is soluble salts, not sodium.
Coastal saline soils contain high concentrations of soluble salts rather than excessive exchangeable sodium on clay particles. Since these soils generally possess high permeability and do not suffer from clay dispersion caused by sodicity, adding gypsum is ineffective. Instead, reclaiming these soils requires physically leaching the soluble salts out of the root zone.

163. (A) The organic matter buffers against structural collapse and improves biological activity.
Applying farmyard manure provides organic matter that acts as a physical binding agent, stabilizing soil aggregates and buffering against structural dispersion. This organic enrichment also stimulates microbial activity and maintains soil permeability, which helps prevent resodification and ensures the long-term sustainability of the reclaimed soil structure.

164. (D) Aerobic respiration
Waterlogging fills all soil pore spaces with water, creating a barrier that blocks atmospheric oxygen from diffusing into the soil. As existing dissolved oxygen is rapidly consumed by roots and microbes, the soil becomes completely anaerobic. In the absence of oxygen, aerobic respiration is eliminated and replaced by anaerobic microbial pathways.

165. (B) II, I, IV, III
As a soil becomes waterlogged, microbes consume electron acceptors in a highly predictable sequence determined by their thermodynamic reduction potentials. Oxygen is reduced first, followed rapidly by nitrate. Once these are depleted, manganese oxides undergo reduction, and eventually, under highly anaerobic conditions with very low redox potential, sulfate reduction occurs.

166. (C) Inducible morphological adaptation
Aerenchyma is specialized gas-conducting tissue that facilitates internal oxygen transport under flooded conditions. When a plant does not possess this tissue under normal conditions but develops it specifically in response to environmental flooding, the response is classified as an inducible morphological adaptation, driven by hormonal signals like ethylene.

167. (D) Surface systems alter topsoil channels; subsurface systems bury conduits below the root zone.
Surface drainage systems rely on modifying the land topography with open ditches or channels to remove excess runoff from the soil surface. Conversely, subsurface drainage systems involve burying perforated pipes or conduits below the

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148. (D) Yield declines significantly before visual symptoms prompt fertilizer application.
Sodic soils have high pH levels that greatly reduce zinc solubility, inducing a sub-clinical deficiency known as hidden hunger. Under these conditions, crop metabolic processes are impaired, leading to a significant reduction in grain yield before any distinct, visible deficiency symptoms appear on the leaves to alert the farmer.

149. (B) Qualitative visual diagnostics
Utilizing indicator crops like sunflower to detect soil imbalances belongs to qualitative visual diagnostics. Sunflower plants are highly sensitive to boron, and they exhibit distinct, observable leaf symptoms when concentrations are too high. This provides a rapid, non-destructive, and practical method for farmers to recognize potential toxicity issues in the field.

150. (C) I and IV
Deep plowing that inverts saline subsoil brings harmful salts up to the surface root zone, which is detrimental to crop growth. Similarly, extensively puddling sodic soils destroys what little structure remains, further reducing water permeability. Both practices are highly discouraged and represent incorrect management strategies for cultivating crops in salt-affected environments.

151. (D) Potential for severe intra-specific competition if germination is high.
Increasing the seed rate is a standard practice used to compensate for poor germination in saline soils. However, if environmental conditions improve and a high percentage of seeds germinate, it can lead to intense intra-specific competition for limited water, nutrients, and light, which ultimately reduces the productivity of individual plants.

152. (A) Rapid synthesis of calcium carbonate in the roots.
Acid-tolerant crop varieties utilize physiological mechanisms such as exuding organic acids to chelate aluminum, sequestering aluminum inside vacuoles, or altering rhizosphere pH. However, plant roots do not physically synthesize calcium carbonate to combat acidity, as this inorganic chemical compound is not produced through biochemical pathways within plant tissues.

153. (B) Permanent increase in soil ESP.
Incorporating Dhaincha as green manure improves sodic soils by increasing organic matter, releasing carbon dioxide to dissolve calcium, and enhancing physical permeability. This process helps lower the exchangeable sodium percentage. Therefore, causing a permanent increase in soil exchangeable sodium percentage is not a benefit, as it contradicts the goals of reclamation.

154. (B) Accumulation of soluble salts in the root zone, causing osmotic stress.
Using high-salinity brackish irrigation water continuously introduces dissolved salts into the soil profile. Without adequate leaching to wash these salts below the root zone, evaporation and plant transpiration cause them to accumulate in the upper soil layers. This accumulation increases osmotic pressure, making it difficult for crops to absorb water.

155. (A) II, I, III, IV
Reclaiming a severely sodic soil must follow a precise sequence. First, the field must be leveled and bunded to ensure uniform water application. Next, gypsum is applied to the soil surface to displace exchangeable sodium. Water is then ponded to leach the displaced sodium, followed by sowing a tolerant crop.

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156. (C) A material with CCE $>$ 100% requires a lower application rate than calcium carbonate.
Calcium carbonate equivalent measures a material's acid-neutralizing capacity relative to pure calcium carbonate. A liming agent with a calcium carbonate equivalent greater than one hundred percent possess higher neutralizing capacity per unit weight. Consequently, a lower physical quantity of this material is required to achieve the same change in soil pH.

157. (D) Manganese
As soil pH drops below four point five, the solubility of manganese compounds increases dramatically. This geochemical shift releases large quantities of manganous ions into the soil solution. Crops growing in these highly acidic soils absorb manganese in excessive, toxic quantities, which disrupts photosynthesis, enzyme activities, and overall plant development.

to prevent long-term soil salinization and structural degradation.

199. (D) The negative logarithm of hydrogen ion activity in soil solution.
Soil pH is a fundamental chemical parameter defined as the negative logarithm of the hydrogen ion activity in the soil solution. This measurement reflects the active acidity of the soil solution, which directly influences nutrient availability, microbial activity, and the solubility of toxic elements like aluminum and manganese.

200. (A) I, II, III and IV
Saline soils develop in arid climates due to high evaporation, while sodic soils are associated with high residual sodium carbonate water. Acid soils form under high rainfall due to cation leaching, and waterlogged soils occur under restricted drainage. However, calcareous soils form from carbonate mineral accumulation rather than organic matter.

201. (B) Non-exchangeable acidity bound to clay and humus, buffering against pH changes.
Residual acidity consists of non-exchangeable hydrogen and aluminum ions that are tightly bound within the structure of clay minerals and humified organic matter. This fraction is not easily displaced or dissolved, and it acts as a massive buffer reservoir that resists changes in soil pH when lime is applied.

202. (B) Inhibited Rhizobium survival and nodulation due to low pH and aluminum.
Legumes require symbiotic Rhizobium bacteria for nitrogen fixation. In highly acidic soils, low pH and toxic concentrations of aluminum severely inhibit the survival of Rhizobium populations and disrupt the root signaling pathways required for nodulation. This failure of nodule formation deprives the legume of nitrogen, leading to poor establishment.

203. (A) Incomplete field mixing and slow dissolution require applying more than laboratory estimates.
Laboratory calculations for lime requirements assume perfect mixing and rapid chemical reactions. In the field, factors such as incomplete soil mixing, coarse limestone particles, and slow dissolution reduce neutralization efficiency. To compensate for these practical limitations, a liming factor is applied, increasing the estimated lime application rate.

204. (C) Chloride toxicity causes marginal leaf burn; sodium causes mottling and necrotic spots.
Sodium and chloride accumulate in tree leaves, but they cause distinct visual symptoms. Chloride toxicity typically manifests as marginal leaf burn, necrosis, and premature leaf drop starting at the leaf tips. In contrast, sodium toxicity tends to cause interveinal chlorosis, mottling, and necrotic spots scattered across the leaf blade.

205. (D) I, II, III and IV
Crops can be arranged in a clear hierarchy based on their physiological salt tolerance. Barley is highly tolerant, followed by wheat, which is classified as moderately tolerant. Chickpea is a sensitive legume, while strawberry is highly sensitive, experiencing severe physiological damage and yield decline at very low salinity levels.

206. (C) Mutual repulsion of clay particles due to thick hydration shells of sodium ions.
The physical degradation of sodic soils is chemically driven by sodium ions, which have a large hydrated radius and weak charge density. When sodium dominates the clay exchange complex, it increases the electrostatic repulsion between clay particles, causing them to disperse, collapse, and block macropores, which destroys soil structure.

207. (B) Cation exchange reaction
When agricultural gypsum is applied to sodic soil, it dissolves to release soluble calcium ions. These divalent calcium ions have a higher affinity for clay exchange sites than monovalent sodium. Through a cation exchange reaction, calcium replaces the exchangeable sodium, allowing the displaced sodium to be leached out as soluble sodium sulfate.

208. (D) The soil is sterile and lacks sulfur-oxidizing bacteria.
Elemental sulfur is not directly soluble or reactive in soil. It requires biological oxidation by specialized autotrophic bacteria, such as Thiobacillus, to produce sulfuric acid, which then dissolves calcium carbonate to release soluble calcium. If the soil is sterile and lacks these sulfur-oxidizing bacteria, this crucial reclamation reaction cannot occur.

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root zone to control the groundwater table and remove excess water from the soil profile.

168. (A) Rising groundwater and excessive leaching of mobile nutrients.
While leaching is essential to control root-zone salinity, applying excessively high leaching fractions can be detrimental. The large volume of deep percolation water can cause local groundwater tables to rise, bringing salts closer to the surface. Additionally, it leaches mobile plant nutrients like nitrates far below the active root zone.

169. (B) High concentration of one ion inhibits root uptake of another.
Specific ion antagonism occurs when an elevated concentration of a particular ion in the soil solution competitively inhibits the uptake of another ion by plant roots. This interference typically happens because the competing ions share similar charge characteristics or use the same membrane transport proteins, leading to induced nutrient deficiencies.

170. (A) Both A and R are true and R is the correct explanation of A.
Applying excess agricultural lime raises the soil pH, which significantly alters chemical equilibria. Under these alkaline conditions, the solubility and availability of key micronutrients, including zinc, manganese, and iron, are drastically reduced. This chemical immobilization prevents root uptake, causing crops like wheat to display distinct visual symptoms of micronutrient deficiencies.

171. (A) Sloping shoulder of the ridge.
In salt-affected fields managed with ridges and furrows, evaporation causes soluble salts to accumulate heavily at the top of the ridge and bottom of the furrow. To protect germinating seeds from this salinity, planting is done on the sloping shoulder of the ridge, where salt concentrations remain relatively low.

172. (C) Priming improves germination vigor; high seed rates compensate statistically for mortality.
Seed priming is a physiological treatment that pre-hydrates seeds, triggering metabolic pathways and improving germination vigor under osmotic stress. Conversely, increasing the seed rate is a statistical management strategy that simply increases the number of seeds sown to compensate for the higher rate of seedling mortality expected in saline soils.

173. (D) IR64-Sub1 (Rice)
CSR 30, KRL 210, and CS 52 are varieties bred specifically for tolerance to soil salinity and alkalinity. In contrast, IR64-Sub1 is a rice variety developed with the SUB_1 gene, which confers tolerance to complete submergence and flooding stress rather than salinity or sodicity tolerance in salt-affected soils.

NODIA

174. (C) The frequency of liming depends on soil cation exchange and buffering capacity.
Applying agricultural lime neutralizes active and reserve soil acidity. How often a field needs liming depends on the soil's cation exchange capacity and buffering capacity, which determine how strongly it resists pH changes. Soils high in clay and organic matter buffer against pH changes and require less frequent, though higher, lime applications.

175. (A) RSC = $(CO_3 2- + HCO_3-)$ - (Ca2+ + Mg2+)
Residual sodium carbonate is an index used to assess the sodium hazard of irrigation water. It is calculated by subtracting the combined milliequivalents of calcium and magnesium ions from the combined milliequivalents of carbonate and bicarbonate ions. This formula helps predict the potential for calcium precipitation and subsequent sodification of the soil.

176. (D) Buffering soil structure against dispersion and maintaining infiltration rates.
Applying organic matter like farmyard manure adds humic substances that bind soil particles, helping maintain structural stability. This aggregation prevents the dispersion of clay particles that often occurs when using high-sodium brackish water. Consequently, soil infiltration and permeability are preserved, allowing for the continued leaching of soluble salts.

177. (A) The equilibrium ESP of the soil solid phase.
The sodium adsorption ratio measures the relative concentration of sodium to divalent calcium and magnesium ions in the soil solution. This ratio is crucial because it directly influences and predicts the equilibrium exchangeable sodium percentage on the soil exchange complex, indicating the risk of clay dispersion and structural degradation.

178. (C) Intense leaching by high annual rainfall in mountains.
Soil sodification requires the accumulation and dominance of sodium ions on the soil exchange complex. Intense leaching by high rainfall in mountainous regions washes basic cations like sodium out of the soil profile, replacing them with hydrogen and aluminum. Therefore, wet mountain leaching is eliminated as a cause, as it promotes soil acidification.

179. (B) Hydrogen ions present in the active soil solution phase.
Active acidity is defined as the concentration of free hydrogen ions present in the soil solution at any given time. This pool of acidity represents only a small fraction of the total soil acidity, but it is the fraction that directly influences chemical reactions, nutrient availability, and plant root growth, and is measured by standard pH electrodes.

180. (A) P-3, Q-1, R-4, S-2
Distinct soil conditions trigger specific physiological responses in crops. Acid soils solubilize toxic aluminum, halting root elongation. Saline soils induce osmotic stress, limiting water uptake. Waterlogged conditions cause hypoxia, prompting plants to form aerenchyma tissue. Finally, the high pH of calcareous sodic soils restricts zinc availability, leading to deficiencies.

181. (B) A larger quantity of low CCE material is needed for the same pH change.
The calcium carbonate equivalent of a liming material determines its acid-neutralizing strength relative to pure calcium carbonate. A material with a low calcium carbonate equivalent has fewer neutralizing components per unit mass. Consequently, a larger quantity of this material must be applied to achieve the desired neutralization and target soil pH change.

182. (C) Accumulating inorganic ions in vacuoles to maintain a favorable osmotic gradient.
Halophytes thrive in highly saline environments by actively absorbing and sequestering inorganic ions, such as sodium and chloride, into their cellular vacuoles. This compartmentalization prevents these ions from causing toxicity in the cytoplasm while lowering the cell's osmotic potential, which allows the plant to continue absorbing water from salty soils.

183. (D) Strawberry
Crops vary widely in their ability to tolerate soil salinity. Barley, cotton, and sugarbeet possess robust physiological tolerance mechanisms, allowing them to produce yields under elevated salt levels. Conversely, strawberry plants are highly sensitive, experiencing severe physiological stress, leaf necrosis, and substantial yield declines at very low salinity levels.

184. (A) Destruction of soil aggregation, leading to surface crusting and poor aeration.
In agriculture, the dispersion of clay micelles is highly detrimental. This process breaks down soil aggregates, causing the dispersed clay particles to clog soil pores. Upon drying, this results in the formation of a hard surface crust that restricts water infiltration and impedes aeration, leading to poor crop growth and development.

185. (D) 10%
Calculating the gypsum requirement determines the amount of gypsum needed to displace excess exchangeable sodium. The ultimate goal of this chemical reclamation is to reduce the exchangeable sodium percentage to a safe level, typically around ten percent, which prevents clay dispersion and restores favorable physical properties to the soil.

186. (B) Press mud (sulfitation)
Press mud from the sulfitation process in sugar mills serves a dual purpose as an agricultural amendment. It acts as a nutrient-rich organic manure, improving soil structure and biological activity. Due to its elevated sulfur content, it also undergoes microbial oxidation to produce sulfuric acid, helping neutralize soil alkalinity.

187. (C) -150 to -200 mV
In flooded soils, sequential reduction of electron acceptors occurs as redox potential drops. Sulfate reduction is a highly anaerobic process that requires a very low redox potential. This reduction to hydrogen sulfide typically begins once the soil redox potential drops to between negative one hundred fifty and negative two hundred millivolts.

188. (C) Hypoxia from waterlogging
Low-lying, poorly drained areas accumulate excess water, leading to localized saturation. This waterlogging fills soil pores, blocking oxygen diffusion and creating an anaerobic root zone.

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Under these hypoxic conditions, root respiration is severely restricted, causing impaired nutrient uptake and manifesting as severe stunting and leaf yellowing in affected plants.

189. (D) Surface drains require land shaping; subsurface drains require high initial capital.
Installing surface drainage requires modifying the land topography with slopes and open channels to remove surface runoff. In contrast, installing subsurface tile drainage systems involves high initial capital costs for excavation, purchasing, and burying perforated pipes below the root zone, but it provides superior, long-term control over the groundwater table.

190. (C) I and II
The simplest steady-state leaching requirement formula relates the amount of salt entering the soil to the amount leaving. It is calculated as the ratio of the electrical conductivity of the irrigation water to the permissible electrical conductivity of the drainage water. Therefore, only these two parameters are fundamentally required for this basic calculation.

191. (B) Enhanced phosphorus uptake from high zinc.
In sodic soils, excessive exchangeable sodium competes with other cations, causing deficiencies in calcium and potassium, while high carbonate levels reduce magnesium activity. However, high zinc levels do not enhance phosphorus uptake; instead, phosphorus and zinc exhibit a well-known antagonistic relationship where high phosphorus levels induce zinc deficiency in plants.

192. (D) Alfalfa
Alfalfa is highly sensitive to soil acidity and soluble aluminum. When grown in low pH soils, its root development is severely inhibited, and the plant exhibits clear, early symptoms of nutritional stress and poor growth. Because of this high sensitivity, alfalfa is used as a reliable visual indicator for soil acidity.

193. (A) Sprinkler irrigation washes accumulated salts from the bed top back into the root zone.
Raised beds help avoid salinity by allowing salts to migrate upward to the bed top via capillary action, keeping the lower root zone relatively salt-free. However, if overhead sprinkler irrigation is used, the falling water droplets physically wash these accumulated salts from the bed top back down into the active root zone.

194. (C) It keeps soil moisture high, preventing salts from concentrating in small water volumes.
Irrigating frequently keeps the soil moisture content near field capacity. This continuous wetness dilutes the concentration of soluble salts in the soil solution, preventing them from concentrating in small water volumes as the soil dries. Consequently, the soil's osmotic potential remains high, making it easier for crop roots to absorb water.

NODIA

195. (A) I, II, III, IV
Establishing a crop in moderately saline soils requires a logical sequence of management practices. First, a heavy pre-sowing irrigation is applied to leach soluble salts from the surface soil. Next, salt-tolerant cultivars are selected, followed by seed priming to enhance germination. Finally, sowing is done on the sloping sides of ridges.

196. (D) They tolerate high internal concentrations of aluminum.
Tea plants are calcifuge species that thrive in highly acidic soils. Their adaptation is driven by their ability to absorb and tolerate high internal concentrations of aluminum within their tissues. Rather than suffering from aluminum toxicity, tea plants utilize the absorbed aluminum to support various physiological functions and stimulate growth.

197. (B) Using plants and organic decay to improve soil structure and remove salts.
Bio-amelioration refers to using plants and organic materials to reclaim degraded soils. The roots of tolerant crops physically improve soil structure and water infiltration, while decomposing organic matter releases carbon dioxide and organic acids. This process solubilizes native calcium, which displaces exchangeable sodium and helps leach salts from the root zone.

198. (C) It requires constant monitoring to prevent soil salinization and degradation.
Conjunctive use blends fresh canal water with saline brackish water, expanding the overall irrigation supply. However, the main disadvantage of this practice is the continuous addition of salts to the soil. This requires careful, constant monitoring of soil salinity and sodicity

growth and reproductive yield, representing a major energetic cost and disadvantage for crop plants striving to survive under high soil salinity.

119. (D) Salinity threshold
In crop yield response models, the salinity threshold represents the specific electrical conductivity of the soil saturated extract at which relative yield first begins to decrease. Below this threshold value, salinity does not adversely affect crop yield, but as salinity levels exceed this baseline, agricultural productivity begins to decline linearly or non-linearly.

120. (A) I, II and III
High sodicity causes clay particles to disperse and organic matter to dissolve, which severely disrupts soil structure. This structural breakdown reduces water infiltration rates, blocks macropores to cause poor soil aeration, and forms a hard surface crust upon drying. Conversely, sodic soils become extremely hard and cloddy rather than showing increased physical friability.

121. (B) The amount of gypsum needed to replace exchangeable sodium from the soil root zone.
Gypsum requirement is defined as the total quantity of agricultural gypsum needed to displace excessive exchangeable sodium ions from the soil exchange complex. The calcium ions supplied by gypsum physically replace sodium on the clay surfaces, enabling the displaced sodium to be leached out of the active root zone, thereby reclaiming the sodic soil.

122. (B) An increase in soil CO_2 partial pressure, which lowers pH and dissolves native calcite.
Applying farmyard manure promotes microbial respiration, which significantly increases the partial pressure of carbon dioxide in the soil air. This carbon dioxide reacts with water to form carbonic acid, which lowers the soil pH and enhances the dissolution of native calcium carbonate, releasing soluble calcium to displace exchangeable sodium from the clay complex.

123. (A) The biological reduction of sulfate by anaerobic bacteria under low redox potentials.
Under severely prolonged waterlogged conditions, the depletion of oxygen drops the soil redox potential to very low levels. Under these anaerobic conditions, specialized sulfate-reducing bacteria utilize sulfate as an electron acceptor, biologically reducing it into hydrogen sulfide gas, which can accumulate to toxic concentrations and damage crop roots in submerged environments.

124. (C) The plant is adapting to facilitate oxygen entry and vent toxic volatile metabolites.
Hypertrophied lenticels are specialized, enlarged pore structures that develop on the stems of water-tolerant plants during flooding. These structures physiologically adapt the plant to facilitate the entry of atmospheric oxygen into the waterlogged tissues while simultaneously allowing the venting of toxic volatile metabolites, such as ethanol and acetaldehyde, produced during anaerobic root respiration.

125. (D) Determining the flow velocity of drainage water within open surface channels
In agricultural drainage design, Manning's equation is a fundamental mathematical formula used to estimate the uniform flow velocity of water inside open surface channels or conduits. It relates water velocity to channel roughness, hydraulic radius, and slope, enabling engineers to size drainage canals correctly to prevent waterlogging and facilitate regional salt disposal.

126. (C) To maintain root-zone salinity below the threshold that causes economic yield decline.
The primary objective of implementing leaching practices is to continuously wash excess soluble salts out of the active root zone. By controlling this salt balance, farmers ensure that the electrical conductivity of the soil solution remains below the specific salinity threshold of the crop, thereby preventing osmotic stress and avoiding economic yield decline.

127. (B) High absolute availability of soluble iron (Fe2+) in the soil profile
Calcareous soils are characterized by high calcium carbonate content and alkaline pH levels, which severely restrict the solubility of iron. Under these alkaline conditions, the availability of soluble ferrous iron in the soil profile is extremely low. Therefore, high absolute availability of soluble iron is completely eliminated as a cause of iron chlorosis.

128. (D) Exhibits clear symptoms of nutrient deficiency or toxicity earlier than the main crop.
Indicator plants possess a high sensitivity to specific environmental conditions, nutritional deficits, or chemical toxicities. Because of this

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209. (A) Increases due to reduction of insoluble Fe3+ to soluble Fe2+.
Waterlogging quickly depletes soil oxygen, forcing anaerobic microbes to use alternative electron acceptors. Under these reducing conditions, insoluble ferric iron is biologically reduced to soluble ferrous iron. Consequently, the concentration of soluble ferrous iron in the soil solution increases significantly, sometimes reaching levels that can cause toxicity in crops.

210. (C) Recycling NAD+ via controlled fermentation to maintain glycolysis during hypoxia.
During anoxia, aerobic respiration is blocked, and glycolysis is the only pathway available to produce ATP. To sustain glycolysis, cells must regenerate NAD+ from NADH. Genetically enhancing the controlled fermentation pathway allows the plant to recycle NAD+ efficiently, maintaining a steady supply of energy for cell survival under waterlogged conditions.

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2025

18. When comparing C_3 and C_4 crops under drought stress, why do C_4 crops generally maintain higher productivity?

(A) They possess a much lower affinity for carbon dioxide at the active binding site of PEP carboxylase

(B) They completely lack bundle sheath cells, which reduces the baseline energy cost of maintaining tissues

(C) They concentrate carbon dioxide around Rubisco to sustain photosynthesis under closed stomata

(D) They automatically switch to secondary CAM metabolism under conditions of severe water deficit

2013

19. What is the optimal soil pH range for the cultivation of wheat?

(A) 4.5 to 5.5

(B) 6.0 to 7.5

(C) 8.0 to 9.0

(D) 9.0 to 10.5

2019

20. How is electrical conductivity (EC) defined in the context of soil analysis?

(A) The direct measurement of the magnetic field generated by metallic soil minerals

(B) The average speed at which gravity-fed water moves downward through the soil profile

(C) The total net electrical charge of all colloidal organic matter in a soil sample

(D) The soil's capacity to conduct current, indicating soluble salt concentration

2017

21. How is the gypsum requirement for an alkaline soil determined?

(A) By measuring the total insoluble calcium carbonate equivalent of the topsoil layer

(B) By determining the exchangeable sodium percentage replaced by calcium

(C) By calculating the total amount of soluble chlorides present in the saturation extract

(D) By determining the precise baseline saturation of exchangeable potassium and magnesium

2011

22. Which statement correctly identifies the relationship between crop type and salinity tolerance?

(A) Grain legumes like beans and peas are classified as highly tolerant to soil salinity

(B) Sugarcane crops thrive exceptionally well when the active soil EC exceeds 10 dS/m

(C) Barley and cotton possess high tolerance to elevated soil EC

(D) Rice plants are highly tolerant to salinity during their seedling and tillering stages

2010

23. Match the crops in List I with their characteristic soil pH adaptations in List II:

List I: (Crop)

P. Tea

Q. Barley

R. Potato

S. Alfalfa

List II: (Soil pH Adaptation)

1. Moderately acidic to neutral (5.0–6.5)
2. Highly acidic (4.5–5.5)
3. Neutral to slightly alkaline (6.5–8.0)
4. Mildly alkaline (7.0–8.5)

(A) P-1, Q-3, R-2, S-4

(B) P-3, Q-2, R-4, S-1

(C) P-4, Q-1, R-3, S-2

(D) P-2, Q-4, R-1, S-3

NODIA

2003

24. Which statement about soil physical and chemical prerequisites is INCORRECT?

(A) A higher soil pH generally increases the availability of micronutrients like iron and zinc

(B) Saline soils are characterized by an electrical conductivity greater than 4 dS/m and a pH less than 8.5

(C) Soil bulk density typically increases when excessive heavy machinery causes compaction

(D) Sodic soils possess an exchangeable sodium percentage greater than 15

2011

25. What is the primary cause of poor soil structure and reduced infiltration in alkali (sodic) soils?

(A) Excessive accumulation of soluble calcium and magnesium sulfates in topsoil

(B) Dispersion of clay particles by high exchangeable sodium

(C) Flocculation of stable clay particles induced by high organic matter content

(D) Rapid leaching of stable iron and aluminum oxides from the upper topsoil

2011

26. Which of the following crops is an exception to the general rule of high sensitivity to waterlogged, anaerobic soil conditions?

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(B) Potato
(C) Cassava
(D) Peanut

2021
9. In comparing the Mesoamerican and Andean centers of origin, which trait is most characteristic of the crops domesticated in the Andean center?
(A) Extreme adaptation to hot, humid lowland tropical basins
(B) Adaptation to cool, high-altitude climates
(C) Near-exclusive reliance on wind-mediated pollination
(D) Complete absence of any tuberous or root crops

2004
10. Which of the following is a classic example of a C_4 field crop?
(A) Oryza sativa
(B) Zea mays
(C) Triticum aestivum
(D) Glycine max

2023
11. What is the fundamental definition of photoperiodism in crop physiology?
(A) The biological response of plants to relative day and night lengths
(B) The continuous diurnal tracking of solar movement by active crop leaves
(C) The net rate of carbon fixation under fluctuating ambient light intensities
(D) The biological emission of light by specialized plant tissues under stress

2003
12. How is the concept of Growing Degree Days (GDD) primarily applied in crop management?
(A) To calculate the total volumetric requirements of seasonal irrigation water
(B) To measure the cumulative amount of solar radiation intercepted by the canopy
(C) To predict plant growth stages such as flowering and maturity
(D) To determine the optimum application rates of primary basal fertilizers

2010
13. Which statement accurately describes the Crassulacean Acid Metabolism (CAM) pathway in crops like pineapple?
(A) Stomata remain wide open during daytime hours and close tightly at night to fix carbon
(B) The initial carbon fixation occurs in bundle sheath cells rather than mesophyll cells
(C) Photorespiration rates are exceptionally elevated during hot conditions compared to C_3
(D) Stomata open at night for carbon fixation, closing during the day to save water

2024
14. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Thermoperiodism significantly influences the reproductive phase in many temperate crops.
Reason (R): Alternating day and night temperatures regulate enzymatic activities critical for floral induction and development.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024
15. Which statement regarding the metabolic classification of crops is INCORRECT?
(A) C_4 plants typically have higher water-use efficiency than C_3 plants
(B) The first stable product of carbon fixation in C_3 plants is oxaloacetic acid
(C) C_3 plants exhibit significant levels of photorespiration under high temperatures
(D) Kranz anatomy is a distinguishing structural feature of C_4 plant leaves

2013
16. What is the primary effect of elevated photorespiration in C_3 crops during periods of high temperature and high light intensity?
(A) Significantly increased net photosynthetic yield and total sugar accumulation
(B) Highly accelerated opening of stomata causing rapid moisture transpiration
(C) Immediate transition of the standard photosynthetic pathway to C_4 metabolism
(D) Reduced net carbon assimilation leading to lower dry matter yield

2024
17. All of the following crops are classified as short-day plants for floral induction EXCEPT:
(A) Wheat
(B) Rice
(C) Soybean
(D) Sorghum

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2017

51. Which statement regarding finger millet (Eleusine canacana) agronomy is INCORRECT?
(A) It is predominantly cultivated as a direct-seeded, rainfed crop without nursery preparation
(B) It is highly valued for the exceptionally long storage life of its grain, which resists common storage pests
(C) It possesses a high calcium content compared to other major cereals
(D) It is highly adaptable to varied elevations and diverse soil types

2017

52. What is the physiological cause and effect of leaf rolling in sorghum during a severe dry spell?
(A) High internal turgor pressure causes specialized bulliform cells to expand, exposing more total leaf area to direct sunlight
(B) Excessive nitrate nitrogen accumulation in the leaf midrib physically forces the margins to curl downward under stress
(C) The complete irreversible degradation of chlorophyll under intense heat permanently changes the internal leaf structure
(D) Loss of turgor in bulliform cells rolls leaves inward to reduce exposed area and transpiration

2024

53. All of the following are major diseases causing significant economic loss in pearl millet EXCEPT:
(A) Downy mildew (Green ear disease)
(B) Karnal bunt
(C) Ergot
(D) Smut

2005

54. When comparing sorghum and maize for drought tolerance, which factor gives sorghum a distinct advantage?
(A) Sorghum maintains significantly higher baseline transpiration rates under severe environmental stress
(B) Zea mays roots penetrate much deeper and extract soil water much more efficiently than sorghum
(C) Sorghum can remain dormant during drought and resume growth when moisture is available
(D) Maize requires a significantly lower base physiological temperature for successful seed germination

2017

55. Which specific species of Rhizobium is commercially used for inoculating soybean seeds?
(A) Rhizobium leguminosarum
(B) Mesorhizobium ciceri
(C) Rhizobium meliloti
(D) Bradyrhizobium japonicum

2001

56. What is the agronomic definition of "nipping" in chickpea cultivation?
(A) Plucking apical buds of young plants to promote lateral branching
(B) The precise application of selective post-emergence herbicides to kill broadleaf weeds
(C) The manual physical removal of diseased lower leaves to prevent systemic fungal spread
(D) Harvesting the immature pods while they are still green for localized vegetable use

2002

57. Which concept accurately describes the mechanics of biological nitrogen fixation in pulse crops?
(A) The active plant roots physically secrete gaseous nitrogen directly into the surrounding soil atmosphere
(B) Symbiotic bacteria in nodules convert atmospheric nitrogen into ammonia
(C) Free-living soil bacteria convert inorganic nitrate into gaseous atmospheric nitrogen to provide energy
(D) The green leaves absorb nitrogen dioxide from the ambient air and transport it downwards to the roots

NODIA

2022

58. Which statement correctly identifies the function of leghemoglobin in pulse crop root nodules?
(A) It serves as the primary catalytic enzyme that physically splits the atmospheric nitrogen triple bond
(B) It binds oxygen, maintaining a microaerobic nodule environment
(C) It actively transports newly fixed ammonia from the root nodules to the upper vegetative leaves
(D) It actively protects the developing nodule from direct invasion by pathogenic soil nematodes

2008

59. Match the pulse crops in List I with their corresponding specific Rhizobium inoculants in List II:

(A) Maize
(B) Rice
(C) Chickpea
(D) Sunflower

2019

27. In comparing saline and sodic soils, which visual characteristic is most uniquely associated with severe sodicity?
(A) Black surface spots caused by dissolved organic matter
(B) A prominent white crust of soluble salts on the soil surface in dry seasons
(C) High levels of macro-organism activity and excellent granular crumb structure
(D) Reddish iron oxide staining located immediately adjacent to the active root zone

2004

28. Which variable is NOT required when calculating the theoretical plant population per hectare?
(A) Row-to-row spacing
(B) Plant-to-plant spacing
(C) Germination percentage
(D) Area of one hectare

2001

29. What is the standard agronomic definition of zero tillage?
(A) Plowing the soil deeply once every five years using heavy subsoilers to break the hardpan
(B) Using purely manual hand tools instead of heavy mechanized equipment for complete soil inversion
(C) Completely removing all crop residue fractions before sowing seeds in deeply disturbed soil
(D) Planting crops into unprepared soil leaving at least 30 percent residue cover

2005

30. How does the real value (utility percentage) of seed influence the seed rate calculation?
(A) A lower real value dictates a proportional and significant decrease in the required seed rate
(B) The real value alters the required row-to-row spacing but does not directly affect the seed rate
(C) A lower real value requires increasing the seed rate to achieve the target stand
(D) The real value is exclusively used to calculate the economic cost of seed, not the physical quantity

2022

31. Which statement correctly outlines a principle of sowing depth in field crops?
(A) Small-seeded crops like mustard require deeper sowing than large-seeded crops like maize
(B) Coleoptile length is the primary determinant of maximum safe sowing depth in cereals
(C) Seeds must always be placed below the moisture zone regardless of soil temperature
(D) Epigeal germinating crops can be safely sown much deeper than hypogeal ones

2022

32. Select the correct standard sequence of tillage operations for a conventionally prepared seedbed:
(A) Planking, Primary plowing, Harrowing, Sowing
(B) Harrowing, Primary plowing, Sowing, Planking
(C) Sowing, Primary plowing, Planking, Harrowing
(D) Primary plowing, Harrowing, Planking, Sowing

2025

33. Which statement regarding crop geometry and stand establishment is INCORRECT?
(A) Higher plant populations always result in a linear increase in per-plant economic yield
(B) Rectangular planting allows for easier mechanical inter-cultivation compared to broadcast sowing
(C) Square planting arrangements minimize intra-specific competition between adjacent plants
(D) Crop geometry dictates the spatial arrangement and available area per individual plant

2013

34. What is the direct agronomic effect of subsoiling or deep tillage in a field with a documented hardpan?
(A) Accelerated upward capillary movement of harmful salts directly to the soil surface
(B) An immediate and significant increase in the total organic nitrogen content of the subsoil
(C) Destruction of the hardpan for deeper root penetration and moisture extraction
(D) Complete and permanent prevention of weed seed germination throughout the soil profile

2014

35. All of the following are recognized advantages of conservation tillage EXCEPT:

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CHAPTER 06
Crop Production

NODIA

2019

1. Which geographical region is considered the primary center of origin for maize according to Nikolai Vavilov's gene center theory?
(A) Mesoamerica
(B) Central Asia
(C) South America
(D) Mediterranean

2004

2. How is a center of diversity academically defined in crop agronomy?
(A) An area characterized by the highest commercial production of a crop
(B) The location where a target crop was first successfully genetically modified
(C) A geographic region where a crop exhibits the greatest genetic variation
(D) The territory possessing the highest overall soil fertility for a crop

2021

3. How does the identification of microcenters assist in crop improvement programs?
(A) By offering localized areas of rich wild diversity for germplasm collection
(B) By concentrating modern hybrid seed stock for immediate commercial release
(C) By identifying isolated zones with zero insect pest incidence for seed multiplication
(D) By determining the maximum genetic yield potential under optimal nutrient inputs

2018

4. Which statement correctly distinguishes a primary center of origin from a secondary center?
(A) A primary center possesses cultivated crop varieties only, whereas a secondary center contains mostly wild species
(B) A secondary center is always characterized by dominant alleles, whereas a primary center contains recessive genes
(C) A secondary center typically covers a significantly larger geographical land mass than a primary center of origin
(D) A primary center is the area of initial domestication, while a secondary center develops diversity later

2015

Consider the following statements regarding Vavilovian centers of origin:
I. The Near East center is the origin of wheat and barley.
II. The Indian center is the primary origin of soybean.
III. The Mediterranean center is known for forage crops like white clover.
Which of the above statements are correct?
(A) I only
(B) I and III
(C) II and III
(D) II only

2001

6. Which statement INCORRECTLY describes the geographical distribution of major field crops?
(A) Rice cultivation is primarily concentrated in South and Southeast Asia
(B) Sorghum is widely distributed across the semi-arid tropics
(C) Wheat adaptation is restricted exclusively to temperate climatic zones
(D) Soybean production is highly concentrated in the Americas and East Asia

2005

7. What is the primary cause for the successful adaptation of potato, originally from the Andes, to European latitudes?
(A) Increased susceptibility to late blight in higher latitudes
(B) Spontaneous doubling of chromosomes in European soils
(C) Transition from vegetative propagation to true potato seed planting
(D) Selection for day-neutral or long-day tuberization traits

2017

8. All of the following crops have their primary center of origin in the South American center EXCEPT:
(A) Sorghum

promoting the rapid breakdown of toxic soil organic acids
(D) It systematically prevents the germination of all competitive aquatic weed species entirely

2024
44. All of the following practices are standard components of the System of Rice Intensification (SRI) EXCEPT:
(A) Using a mechanical weeder (cono-weeder) for soil aeration
(B) Applying strictly regulated alternate wetting and drying irrigation schedules
(C) Transplanting 30-day-old seedlings to ensure field survival
(D) Relying extensively on organic manures for nutrient management

2019
45. In comparing aerobic rice to traditional flooded rice, what is a primary agronomic trade-off?
(A) Aerobic rice completely and permanently eliminates weed management problems compared to flooded rice
(B) Aerobic rice requires massive and continuous amounts of standing water during its vegetative phase
(C) Aerobic rice exhibits significantly higher cumulative methane emissions compared to flooded rice systems
(D) Higher water-use efficiency but lower overall yield potential than flooded rice

2013
46. What specific anatomical feature contributes significantly to the drought adaptation mechanism in sorghum?
(A) Extremely large, thin leaf structures coupled with exceptionally high stomatal density
(B) A very shallow, fibrous root system strictly confined to the top five centimeters of soil
(C) Silica accumulation and heavy waxy bloom on the leaf epidermis
(D) The complete physiological absence of motor cells or bulliform cells in the leaves

2025
47. How is osmotic adjustment defined as a drought tolerance mechanism in millets?
(A) The systematic shedding of older leaves to reduce the cumulative transpiring surface area of plants
(B) Accumulating cellular solutes to maintain turgor at low water potentials
(C) The rapid physical closure of stomatal pores triggered directly by synthesized abscisic acid
(D) The dense formation of a protective waxy layer over the stomatal pores to block overall gas exchange

2013
48. Why do millets generally exhibit a higher water-use efficiency compared to most C_3 cereals?
(A) They have exceptionally high rates of transpiration that help cool the canopy rapidly
(B) They completely lack stomata on the upper leaf epidermis, reducing water loss by half
(C) They routinely undergo Crassulacean Acid Metabolism under periods of severe drought stress
(D) They possess the C_4 pathway, minimizing photorespiration and saving water

2015
49. Which statement correctly identifies a key cultural trait of pearl millet (Pennisetum glaucum)?
(A) A strong tillering ability that compensates for sparse plant populations
(B) It is extremely sensitive to elevated temperatures, requiring cool nights for successful panicle emergence
(C) It strictly requires continuous soil submergence or flooding during its early vegetative growth phase
(D) It is classified as an obligate self-pollinated crop, making commercial hybrid seed production impossible

2006
50. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Young sorghum plants are generally considered unsafe for feeding directly to livestock.
Reason (R): Sorghum seedlings and new tillers accumulate high levels of dhurrin, a cyanogenic glycoside that releases toxic prussic acid.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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(C) Late pod filling and physiological maturity stage
(D) Primary branch initiation and leaf senescence stages

2001

68. Consider the following statements regarding specific operations in groundnut cultivation:
I. Pegging requires soft, friable soil for optimal penetration.
II. Gypsum is applied primarily to supply nitrogen during pod development.
III. Earthing-up is essential to avoid the exposure of developing pods to sunlight.
IV. The crop is highly tolerant to waterlogging during the flowering stage.
V. Calcium deficiency directly results in the formation of 'pops' or unfilled pods.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III, IV and V
(C) I, II, III and V
(D) I, III and V

2012

69. Which statement INCORRECTLY describes the cultivation practices for sesame?
(A) Sesame requires an exceptionally fine seedbed due to its small seed size
(B) The broadcasting seed rate is 15–20 kg per hectare
(C) Sesame crops are extremely sensitive to any waterlogged soil conditions
(D) The sesame crop is characterized by an indeterminate growth habit

2003

70. What is the specific cause and effect relationship governing gypsum application at the pegging stage of groundnut?
(A) Gypsum lowers soil pH to highly acidic levels, preventing the spread of soil-borne fungal pathogens
(B) Gypsum supplies excess sulfur that directly increases the total crude protein content of the foliage
(C) Gypsum supplies localized calcium directly to the pod, preventing unfilled pops
(D) Gypsum hardens the surface soil crust, physically protecting developing pegs from subterranean insect damage

2012

71. Which of the following oilseed crops has the highest relative requirement for sulfur application due to its role in glucosinolate synthesis?
(A) Indian mustard
(B) Sunflower
(C) Groundnut
(D) Sesame

2001

72. In comparing the drought tolerance mechanisms of safflower and sunflower, what represents a primary difference?
(A) Safflower relies on a deep taproot for moisture, while sunflower needs frequent irrigation
(B) Sunflower possesses a significantly thicker waxy cuticle than safflower to completely eliminate cuticular water loss
(C) Safflower stems store massive physiological reserves of water akin to desert succulents, unlike sunflower
(D) Sunflower undergoes rapid and complete defoliation under mild moisture stress, whereas safflower retains its leaves

2017

73. How is the ginning outturn (GOT) percentage calculated in cotton processing?
(A) $\frac{\text{Weight of seed}}{\text{Weight of lint}} \times 100$
(B) $\frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$
(C) $\frac{\text{Weight of seed cotton}}{\text{Total plant bio mass}} \times 100$
(D) $\frac{\text{Length of staple}}{\text{Weight of lint}} \times 100$

NODIA

2005

74. What is the fundamental biochemical process involved in the retting of jute?
(A) The aggressive physical and mechanical crushing of stalks to extract intact fibers
(B) Microbial breakdown of pectins and gums binding fibers to the stem core
(C) The chemical bleaching of raw extracted fibers using chlorine solutions to improve luster
(D) The thermal and chemical degradation of structural lignin under elevated temperatures

2005

75. Why is chemical defoliation frequently utilized in mechanized cotton production?
(A) To remove leaves before harvest to reduce

List I: (Pulse Crop)
P. Chickpea
Q. Alfalfa / Lucerne
R. Pea
S. Soybean
List II: (Rhizobium Inoculant)
1. Rhizobium leguminosarum
2. Mesorhizobium ciceri
3. Bradyrhizobium japonicum
4. Rhizobium meliloti
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-1, R-3, S-2

2001

60. Which statement about the role of phosphorus in pulse crop agronomy is INCORRECT?
(A) Phosphorus is crucial for root development and nodule mass proliferation
(B) A starter dose of nitrogen combined with adequate phosphorus enhances early seedling vigor
(C) Phosphorus application heavily depresses nodule formation and nitrogen fixation
(D) Pulse crops generally have a higher requirement for phosphorus than for applied synthetic nitrogen

2001

61. What is the cause and effect of an early attack by the gram pod borer (Helicoverpa armigera) on chickpea?
(A) It causes the plant to abort all its vegetative branches, stunting growth permanently
(B) The feeding damage induces a hyper-allergic response, causing sudden wilting of the entire plant
(C) It stimulates the plant to produce larger seeds in the surviving pods, compensating entirely for the loss
(D) Larvae feed on the developing flowers and young pods, leading to a drastic reduction in seed yield

2021

62. Among the commonly grown grain legumes (pulses), which one is a notable exception because it generally lacks effective root nodulation under natural field conditions in India?
(A) Mungbean (Vigna radiata)
(B) Urdbean (Vigna mungo)
(C) French bean (Phaseolus vulgaris)
(D) Pigeonpea (Cajanus cajan)

2013

63. When comparing the germination patterns of pulse crops, which comparison is correct?
(A) Soybean exhibits standard hypogeal germination, whereas chickpea exhibits epigeal germination
(B) Mungbean exhibits epigeal, and pigeonpea exhibits hypogeal germination
(C) Both pigeonpea and mungbean plants exhibit identical hypogeal germination patterns
(D) Groundnut exhibits standard hypogeal germination, whereas pea exhibits epigeal germination

NODIA

2006

64. At what days after sowing does the critical physiological stage of pegging typically begin in bunch-type groundnut varieties?
(A) 15 to 20 days
(B) 40 to 45 days
(C) 75 to 80 days
(D) 95 to 100 days

2009

65. What is the specific purpose of earthing-up in sunflower cultivation?
(A) To support the stem physically, preventing lodging from heavy heads and wind
(B) To bury fallen seeds into the soil profile to induce a rapid second crop flush
(C) To bury emerging early-season weeds completely under a thick, deep layer of soil
(D) To create robust physical barriers against common crawling and creeping insect pests

2012

66. How is flower and pod drop typically managed in pulse and oilseed crops through hormonal application?
(A) By spraying highly concentrated gibberellic acid to accelerate the onset of flowering
(B) By using heavy surface applications of abscisic acid to induce early bud dormancy
(C) By foliar spraying dilute NAA at the pre-flowering or early flowering stage
(D) By systematically drenching the rhizosphere soil with pressurized ethylene gas

2022

67. Which statement correctly identifies the critical moisture-sensitive stages in Indian mustard (Brassica juncea)?
(A) Pre-flowering (rosette) and early siliqua formation
(B) Sowing to emergence and early vegetative rosette stage

(A) Complete and immediate eradication of perennial weed populations
(B) Reduction of soil erosion caused by wind and water
(C) Enhanced conservation of soil moisture
(D) Reduction in fuel and labor costs associated with land preparation

2022
36. When comparing the broad bed furrow (BBF) system to flat bed planting in vertisols, what is the primary advantage of BBF?
(A) It completely eliminates any requirement for applying basal chemical fertilizers
(B) It significantly reduces the long-term energy and labor cost of land preparation
(C) It systematically allows for much higher seeding densities than standard flat bed planting
(D) It drains excess water safely and conserves moisture during dry spells

2003
37. What is the typical duration required for rice seedlings to be ready for transplanting under the Dapog nursery method?
(A) 11 to 14 days
(B) 21 to 25 days
(C) 30 to 35 days
(D) 40 to 45 days

2024
38. How is aerobic cultivation of rice defined?
(A) Growing rice in fully submerged paddies with continuous mechanical aeration of the water
(B) Growing rice exclusively in greenhouse hydroponic systems
(C) Cultivating direct-seeded rice in well-drained, non-puddled, and non-flooded soils
(D) Cultivating traditional deep-water rice varieties in floodplains

2006
39. Which core principle underlines the System of Rice Intensification (SRI)?
(A) Transplanting multiple old, mature seedlings per hill to guarantee dense field stands
(B) Continuous deep flooding of the field to completely suppress all competitive weed growth
(C) Heavy systematic reliance on synthetic chemical fertilizers to boost overall panicle weight
(D) Widely spacing young, single seedlings to promote maximum tillering

2011
40. Which statement regarding the tillering stage in cereal crop agronomy is correct?
(A) Primary tillers emerge from main shoot nodes, and secondary tillers from primary ones
(B) Tillering capacity in irrigated wheat decreases as the spatial spacing between individual plants increases
(C) Every single tiller produced by a cereal plant successfully bears a fertile, productive panicle at harvest
(D) Active tillering strictly and exclusively occurs only after the flag leaf has fully emerged on the shoot

2015
41. Consider the following statements regarding rice cultivation methods:
I. Puddling destroys soil structure and reduces percolation losses.
II. In SRI, fields are kept continuously flooded under 5 cm of water.
III. Dapog seedlings are raised without soil on a concrete or polythene surface.
IV. Aerobic rice requires significantly more water than puddled transplanted rice.
Which of the above statements are INCORRECT?
(A) I, II and III
(B) II and IV
(C) I and III
(D) I, III and IV

2019
42. Which statement INCORRECTLY describes irrigation management in wheat?
(A) The crown root initiation (CRI) stage is highly sensitive to moisture stress
(B) Wheat requires continuous standing water from tillering to physiological maturity
(C) The late jointing and booting stages are critical for determining final grain number
(D) Missing an irrigation at the flowering stage severely limits grain filling and yield

2007
43. What is the primary physical effect of puddling a rice field prior to transplanting?
(A) It forms an impermeable soil layer to reduce deep water percolation
(B) It decreases the cumulative bulk density of the active plow layer on a permanent basis
(C) It thoroughly aerates the root zone,

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lint trash and improve picking efficiency
(B) To accelerate and sustain the vegetative growth of late-emerging flower buds and bolls
(C) To induce premature, artificial opening of immature bolls and maximize the final seed weight
(D) To eliminate and kill pathogenic root-knot nematodes residing deep within the soil profile

2021
76. Which statement correctly identifies a requirement for planting Bt cotton hybrids in India?
(A) Seeds must always be planted at an extremely high density of 200,000 plants per hectare
(B) Bt cotton hybrids cannot be successfully grown if the ambient soil pH is strictly above 7.0
(C) Planting a non-Bt cotton refuge alongside Bt cotton to delay insect resistance
(D) The entire cotton crop must be completely shielded from cross-pollination using physical netting

2017
77. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Ribboning is considered an improved alternative to whole-plant retting in jute processing.
Reason (R): Ribboning requires significantly less water and time for retting while producing higher quality fiber.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012
78. Which statement regarding the growth stages of cotton is INCORRECT?
(A) Square formation refers to the initial appearance of the macroscopic reproductive floral bud
(B) The peak flowering phase is the most physiologically critical stage for soil moisture availability
(C) Shedding of squares is an abnormal symptom caused solely by insect pest attacks
(D) Cotton exhibits a highly indeterminate growth habit, producing vegetative and reproductive organs simultaneously

2023
79. What is the primary cause and effect of excessive nitrogen application during the late vegetative stage of cotton?
(A) It drastically accelerates early boll opening, fiber maturity, and mechanical harvesting
(B) It causes vegetative overgrowth, delaying maturity and increasing sucking pests
(C) It induces severe physiological defoliation of the lower canopy, improving light penetration
(D) It specifically increases the physical staple length of the fiber without affecting overall yield

2006
80. All of the following are classified commercially as bast (stem) fibers EXCEPT:
(A) Jute
(B) Mesta
(C) Sunnhemp
(D) Cotton

2008
81. When comparing Desi cotton (Gossypium arboreum/herbaceum) to American cotton (Gossypium hirsutum), which trait is generally characteristic of Desi cotton?
(A) Greater tolerance to drought and marginal soils
(B) Significantly longer and stronger staple fiber length
(C) Highly elevated susceptibility to jassids and whiteflies
(D) Complete structural absence of sympodial branches

2011
82. What is the standard number of three-budded setts required to plant one hectare of sugarcane using conventional flat planting?
(A) 15,000 to 20,000 setts
(B) 35,000 to 40,000 setts
(C) 60,000 to 70,000 setts
(D) 100,000 to 120,000 setts

NODIA

2014
83. What is the specific purpose of the agricultural practice known as propping in sugarcane?
(A) Tying mature canes with dry leaves to prevent lodging
(B) Digging deep trenches to improve soil aeration and drainage around roots
(C) Applying synthetic chemical ripeners to halt

(C) Boron
(D) Magnesium

2009

144. In comparing fertilizer efficiency metrics, how does Physiological Efficiency (PE) differ from Recovery Efficiency (RE)?
(A) PE evaluates fertilizer cost per unit yield, whereas RE evaluates the market price of the final crop.
(B) PE is applied exclusively to organic wastes, whereas RE is used solely for synthetic chemical fertilizers.
(C) PE measures yield increase per unit nutrient absorbed, whereas RE measures the percentage of applied nutrient absorbed.
(D) Both metrics share identical mathematical formulas, offering no distinction in fertilizer management.

2023

145. At what specific days after sowing does the critical Crown Root Initiation (CRI) stage occur in standard wheat varieties?
(A) 5 to 7 days
(B) 21 to 25 days
(C) 45 to 50 days
(D) 80 to 85 days

2015

146. How is the crop coefficient (K_c) defined in the calculation of crop water requirements?
(A) The ratio of the crop's harvested economic yield to the total volume of irrigation water applied to the field.
(B) The maximum physical depth of the crop's functional root system measured in meters under optimal conditions.
(C) The total percentage of seasonal rainfall that is successfully retained and stored within the active soil profile.
(D) The ratio of actual crop evapotranspiration (ET_c) to the reference crop evapotranspiration (ET_o).

2008

147. Which conceptual formula correctly calculates the total Consumptive Use (CU) of water by a crop?
(A) CU = Transpiration + Evaporation + Water required formet abolic processes
(B) CU = Irrigation water applied + Effective rainfall + Deepper colation losses
(C) CU = Total sea sonal rainfall − Surfacerun off − Water lost viaev a poration
(D) $\text{CU} = \dfrac{\text{Total harvested economic crop yield}}{\text{Sea sonal eva potranspir ationrate}}$

2003

148. Which statement correctly explains the dynamics of evapotranspiration during the crop life cycle?
(A) Soil evaporation dominates during the full canopy stage, while transpiration is negligible.
(B) Evapotranspiration remains constant from sowing until physiological maturity.
(C) Soil evaporation dominates early on, but transpiration dominates once the canopy covers the soil.
(D) Transpiration occurs almost exclusively at night when plant stomatal pores are closed.

2025

149. Match the specific crop in List I with its most critical moisture-sensitive physiological stage in List II:

List I: (Crop)
P. Maize
Q. Groundnut
R. Sugarcane
S. Potato

List II: (Critical Stage)
1. Tuber initiation and development
2. Formative phase
3. Tasseling and silking
4. Pegging and pod formation

(A) P-1, Q-4, R-3, S-2
(B) P-3, Q-2, R-1, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-2, Q-3, R-4, S-1

2005

150. Which statement regarding crop water-use efficiency (WUE) is INCORRECT?
(A) Water-use efficiency is calculated as the economic yield divided by the total water consumed (ET)
(B) Applying adequate fertilizers generally increases water-use efficiency by proportionally increasing crop biomass more than evapotranspiration
(C) Efficient weed control directly improves the water-use efficiency of the main crop
(D) C_4 crops intrinsically exhibit a lower water-use efficiency than C_3 crops under identical climatic conditions

2019

151. What is the cause and effect of severe moisture stress specifically occurring at the flowering or anthesis stage of cereal crops?

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2011

91. At what concentration is Hydrocyanic acid (HCN) in sorghum generally considered safe for livestock feeding?
(A) Below 200 ppm on a dry weight basis
(B) Above 500 ppm on a fresh weight basis
(C) Below 1000 ppm on a fresh weight basis
(D) Above 1500 ppm on a dry weight basis

2011

92. What is the fundamental principle behind successful silage making?
(A) Continuous maximum aeration of the green forage material to promote rapid oxidation
(B) The complete structural dehydration of the green plant material under artificial heat
(C) Anaerobic fermentation of sugars to lactic acid, dropping pH for preservation
(D) The basic alkaline fermentation of plant proteins to produce ammonia for preservation

2006

93. How does optimizing the cutting interval in multi-cut fodder crops balance yield and quality?
(A) Very frequent cutting systematically maximizes total dry matter yield but severely reduces crude protein content
(B) Delaying the harvest cut until full physiological maturity maximizes both total dry matter yield and fodder digestibility
(C) Cutting interval variation has no statistically significant impact on the fiber fractions (NDF/ADF) of the forage
(D) An intermediate cutting interval balances high biomass yield with protein and digestibility

2023

94. Which statement correctly identifies a key principle of hay curing?
(A) The process strictly requires storing the green cut forage in an airtight underground silo
(B) The green forage must be exposed to prolonged, intense sunlight until completely bleached
(C) Reducing moisture to 12–15% rapidly without causing leaf loss
(D) Heavy unexpected rain during the curing process enhances the overall nutritional quality

2023

95. Arrange the biological phases of silage fermentation in the correct chronological sequence:
1. Active lactic acid production phase
2. Aerobic respiration phase
3. Stable preservation phase
4. Initial anaerobic acetic acid production phase

(A) 2, 4, 1, 3
(B) 1, 2, 3, 4
(C) 4, 1, 2, 3
(D) 2, 1, 4, 3

NODIA

2014

96. Which statement regarding anti-nutritional factors in fodder crops is INCORRECT?
(A) Oxalates present in Napier grass bind with calcium, reducing its availability to the animal
(B) Mimosine is a toxic amino acid commonly found in Leucaena leucocephala (Subabul)
(C) Saponins in Lucerne (Alfalfa) can cause severe bloat in ruminants
(D) HCN toxicity in sorghum increases significantly as the crop approaches full maturity

2014

97. What is the cause and effect of robust lactic acid bacterial activity during ensiling?
(A) Lactic acid drops pH below 4.2, inhibiting putrefactive bacteria to preserve forage
(B) The rapid production of lactic acid increases the chemical pH to 7.0, preventing mold growth
(C) Lactic acid bacteria consume all the structural cellulose, making the final silage easily digestible
(D) The bacteria convert excess internal moisture into dry matter, concentrating the target nutrients

2019

98. All of the following are management practices to mitigate anti-nutritional factors in fodder EXCEPT:
(A) Harvesting sorghum only after it crosses the boot stage
(B) Ensiling the fodder, which can significantly reduce HCN and mimosine levels
(C) Applying massive doses of nitrogen fertilizer just before harvesting
(D) Wilting the cut forage in the field for a few hours before feeding

active vegetative growth
(D) Burning the entire field post-harvest to manage remaining crop stubble

2014
84. Which concept underlies the hot water treatment (50°C for 2 hours) of sugarcane setts prior to planting?
(A) It physically softens the hard outer rind to allow faster emergence of adventitious roots
(B) It chemically converts stored internal sucrose into glucose to provide instant energy to the bud
(C) It physically detaches the tough bud scales, ensuring uniform sprouting and field emergence
(D) Eradicating seed-borne pathogens like ratoon stunting and grassy shoot diseases

2024
85. Which statement correctly identifies the advantage of the single-bud seedling transplanting method (SSI) in sugarcane?
(A) It requires a massive total volume of viable seed planting material compared to three-budded setts
(B) It lowers seed requirements while ensuring higher survival and better crop geometry
(C) It completely eliminates the absolute need for any irrigation during the entire hot pre-monsoon period
(D) It exclusively restricts the cane plant to producing a maximum of only two millable stalks per stool

2019
86. Match the sugarcane operations in List I with their appropriate timings or descriptions in List II:
List I: (Sugarcane Operation)
P. Blind hoeing
Q. Earthing up
R. Wrapping
S. Trash mulching
List II: (Timing/Description)
1. Done during the monsoon season to prevent lodging
2. Done immediately after planting but before shoot emergence to break crust
3. Done during the formative phase to conserve soil moisture and suppress weeds
4. Done around 100–120 days to support stalks and provide better drainage
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-1, R-3, S-2

2016
87. Which statement regarding sugarbeet cultivation as an alternative sugar crop is INCORRECT?
(A) Sugarbeet requires a shorter growing duration (5–6 months) compared to sugarcane
(B) It produces sugar stored primarily in its swollen taproot
(C) It requires a cooler climate during its initial growth phases compared to tropical sugarcane
(D) It is highly sensitive to soil salinity and requires completely salt-free soils

2021
88. What is the cause and effect relationship of implementing trash mulching in a sugarcane ratoon crop?
(A) It suppresses weed emergence and conserves soil moisture to improve ratoon vigor
(B) It increases soil temperature excessively, killing the ratoon sprouts
(C) It encourages the rapid multiplication of sugarcane borers in the dry leaves, devastating the crop
(D) It physically blocks the emergence of tillers, reducing the final stalk count

2012
89. All of the following are distinct physiological growth phases in sugarcane EXCEPT:
(A) Formative phase
(B) Tasseling phase
(C) Grand growth phase
(D) Ripening phase

2021
90. When comparing planting materials for sugarcane, how does 'fluff' radically differ from 'setts'?
(A) Fluff constitutes the upper tender succulent portion of the cane, whereas setts are the woody basal sections
(B) Fluff represents true botanical seed from flowers, while setts are vegetative cuttings
(C) Fluff is chemically treated advanced tissue culture material, while setts are standard untreated field canes
(D) Fluff produces clonal plants with identical genetics to the parent, while setts produce high genetic variation

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structure.

(D) It converts the volatile essential oils into highly stable and non-reactive crystalline alkaloids.

2011

107. All of the following are economically important plant-derived alkaloids EXCEPT which one?

(A) Reserpine
(B) Menthol
(C) Atropine
(D) Vincristine

2014

108. When comparing steam distillation to hydro-distillation for extracting essential oils, what is a primary advantage of steam distillation?

(A) It submerges plant material in boiling water to extract water-soluble vitamins and active polar compounds.
(B) It passes steam through the material without boiling, reducing thermal degradation and preventing scorching.
(C) It eliminates the need for external heat energy by utilizing exothermic reactions within the chamber.
(D) It yields a highly concentrated alcoholic extract instead of a pure, volatile essential oil mixture.

2005

109. What is the approximate protein content typically found in the grains of amaranth, a recognized pseudo-cereal?

(A) 4 to 6%
(B) 8 to 10%
(C) 14 to 16%
(D) 25 to 30%

2006

110. How is a pseudo-cereal formally defined in botanical agronomy?

(A) A monocotyledonous grass species producing exceptionally small, high-protein grains for consumption
(B) A nitrogen-fixing legume crop that lacks the biochemical pathways to produce true cereal starch
(C) A non-grass dicot plant whose seeds are used and consumed in the same manner as true cereal grains
(D) An artificial hybrid grain species developed by crossing winter wheat and cereal rye under sterile conditions

2009

111. Which conceptual trait allows under-utilized crops like Job's tears or minor millets to adapt successfully to marginal lands?

(A) Their absolute requirement for deep, fertile loamy soils and continuous synthetic chemical fertilization
(B) Their inability to produce extensive root systems, thereby conserving crucial metabolic energy resources
(C) Their obligate symbiotic relationship with highly specific mycorrhizal fungi found only in degraded soils
(D) Their genetic resilience to severe abiotic stresses, poor soil fertility, and highly erratic rainfall

2025

112. Which statement correctly identifies a unique processing requirement for Quinoa grains before human consumption?

(A) The grains must be physically polished under high pressure to remove a highly toxic layer of heavy metal deposits
(B) The grains must undergo a prolonged submerged fermentation process to neutralize active cyanogenic glycosides
(C) The seeds must be washed or milled to remove bitter saponins present on the outer layer of the seed coat
(D) The seeds must be germinated for three consecutive days to fully activate and synthesize functional gluten proteins

NODIA

2013

113. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R).

Assertion (A): Buckwheat is frequently cultivated in high-altitude mountainous regions.

Reason (R): The crop has an extremely short life cycle, allowing it to mature rapidly during the brief frost-free periods of high-altitude summers.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2006

114. Which statement regarding the nutritional profile of minor millets is INCORRECT?

(A) They generally possess a low glycemic index, making them suitable for diabetic diets

(B) They are notably rich in dietary fiber and essential minerals like calcium and iron compared to polished rice
(C) They are completely gluten-free, addressing specific dietary restrictions
(D) They lack any complex carbohydrates, consisting almost entirely of simple sugars

2007

115. What is the primary cause and effect of early maturity in underutilized pseudo-cereals growing in drought-prone areas?
(A) It allows the crop to escape terminal drought by finishing its life cycle before soil moisture is depleted
(B) It causes the plant to bypass the reproductive phase completely, thereby maximizing total vegetative forage yield
(C) It forces the active root system to absorb high concentrations of salts, increasing individual seed weight
(D) It delays the onset of flowering and pollen release until the arrival of the late winter rain system

2005

116. All of the following are classified as under-utilized pseudo-cereals or minor grains EXCEPT which one?
(A) Grain amaranth
(B) Buckwheat
(C) Triticale
(D) Quinoa

2013

117. When comparing the baking quality of pseudo-cereals (like quinoa or amaranth) to wheat, what is the critical difference?
(A) They lack gluten-forming proteins entirely, causing poor dough elasticity and low leavening capacity.
(B) They contain significantly higher levels of active gliadin, producing superior dough elasticity and rise.
(C) They require much less hydration to form a stable, strong, and highly elastic gluten protein network.
(D) Their starch granules physically block yeast cells, completely preventing the production of carbon dioxide.

2024

118. What was the original purpose behind the development of the Taungya agroforestry system in the 19th century?
(A) To maximize seasonal yields of intensive cash crops like cotton through highly specialized monoculture techniques.
(B) To construct dense, impenetrable biological hedges that protect grazing livestock from local apex predators.
(C) To continuously cultivate high-value, shade-loving medicinal herbs beneath the canopy of mature forest stands.
(D) To establish timber plantations by letting farmers grow food crops alongside tree seedlings in the early years.

2010

119. How is the agri-silviculture system defined within standard agroforestry classifications?
(A) The systematic and intensive integration of high-yielding fruit trees with commercial freshwater aquaculture ponds.
(B) The deliberate, concurrent growing of agricultural crops and forest trees on the same unit of land.
(C) The management of natural pasture lands exclusively for grazing livestock herds without any tree integration.
(D) The rotational slashing and burning of dense forest stands to carry out seasonal subsistence farming activities.

2009

120. Which concept describes allelopathy within tree-crop interactions in agroforestry?
(A) The physical reduction of sunlight reaching understory crops due to the dense canopy of mature trees overhead.
(B) The beneficial sharing of extensive mycorrhizal networks between deep-rooted trees and shallow-rooted crops.
(C) The release of biochemicals by one plant that inhibits the germination, growth, or survival of adjacent species.
(D) The direct physical competition for deep soil moisture reserves between woody tree roots and seasonal crop roots.

2025

121. Which statement correctly characterizes the alley cropping (hedgerow intercropping) system?
(A) Timber trees are planted randomly within open pastures to provide isolated shelter and shade zones for grazing herds.
(B) Trees are prevented from forming any dense canopy cover by applying continuous, aggressive daily pruning of branches.
(C) Food crops are cultivated only after

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completing the absolute clear-cutting of established woody perennial hedgerows.
(D) Food crops are grown in wide alleys formed by rows of fast-growing, nitrogen-fixing leguminous shrubs or trees.

2009
122. Match the agroforestry system classification in List I with its specific components in List II:
List I: (Agroforestry System)
P. Silvi-pasture
Q. Agri-silvi-pasture
R. Horti-silviculture
S. Aqua-forestry
List II: (Components)
1. Trees + Crops + Pasture/Animals
2. Fruit trees + Timber/Fuelwood trees
3. Trees + Fishes
4. Trees + Pasture/Animals
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-3, R-1, S-4

2016
123. Which statement regarding the management of a silvi-pasture system is INCORRECT?
(A) Selected tree species should provide highly nutritious fodder for livestock during critical lean periods.
(B) Continuous, intense overgrazing enhances the establishment and survival of young tree seedlings in pasture.
(C) Selected understory pasture species must exhibit high tolerance to partial shading from tree canopies.
(D) Lopping and pollarding are common canopy management practices used to regulate light penetration to the floor.

2022
124. What is the cause and effect of executing systematic tree root pruning in an established agroforestry system?
(A) It triggers rapid leaf senescence and abscission, which significantly enriches the soil's organic matter content.
(B) It severs lateral feeder roots, reducing below-ground competition for water and nutrients with adjacent crops.
(C) It stimulates the root nodules to fix atmospheric nitrogen at accelerated rates to compensate for lost root biomass.
(D) It alters the geotropic response, forcing the main taproot system to grow upwards into the shallow crop root zone.

2021
125. All of the following are recognized structural classifications of agroforestry systems EXCEPT which one?
(A) Intensive crop monoculture
(B) Agri-silviculture system
(C) Silvi-pasture system
(D) Agri-horticulture system

2018
126. When comparing spatial and temporal arrangements in agroforestry, how does shifting cultivation differ from alley cropping?
(A) Shifting cultivation uses a simultaneous spatial design, whereas alley cropping uses a strictly sequential design.
(B) Shifting cultivation utilizes permanent woody vegetative barriers, whereas alley cropping avoids all barriers.
(C) Shifting cultivation is a sequential temporal system, whereas alley cropping is a simultaneous spatial system.
(D) Both systems are functionally identical, relying on simultaneous spatial arrangements of crops and trees.

2012
127. Which hybrid holds the distinction of being the first commercially released rice hybrid in India?
(A) IR8
(B) Jaya
(C) Pusa Basmati-1
(D) CORH-1

2019
128. How is the process of bio-fortification academically defined in the context of crop improvement?
(A) The physical blending of synthetic vitamins and micronutrient powders into post-harvest processed food products.
(B) The intensive soil application of organic composts and green manures to increase total vegetative biomass yields.
(C) The agronomic or genetic enhancement of food crops to increase the level and bioavailability of essential nutrients.
(D) The protective chemical coating of seeds with highly concentrated bio-pesticides immediately prior to sowing.

2019
129. Which concept correctly outlines the functional mechanism of Cytoplasmic Male Sterility (CMS) in hybrid seed production?

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(A) A nuclear dominant gene prevents the structural development of the female pistils, rendering the flowers completely sterile.
(B) A maternally inherited mitochondrial trait prevents functional pollen production, enabling controlled cross-pollination.
(C) The physical, manual removal of immature anthers from perfect flowers prior to natural pollen dehiscence in the field.
(D) The targeted chemical spraying of selective gametocides that physically and exclusively destroy the receptive stigma.

2009

130. Which statement correctly highlights the significance of the landmark wheat variety 'Kalyansona'?
(A) It was a traditional tall variety bred specifically for extreme waterlogged conditions.
(B) It was an ornamental selection developed solely for its unique dark purple grain pigments.
(C) It was a synthetic hexaploid cultivar produced by crossing domestic barley and wild rye.
(D) It was a semi-dwarf, rust-resistant variety key to India's Green Revolution success.

2021

131. Consider the following statements regarding hybrid seed production using the three-line system:
I. The 'A' line is male sterile and serves as the female parent.
II. The 'B' line is the maintainer line, which is male fertile and is crossed with the A line to multiply A line seeds.
III. The 'R' line is the restorer line, which restores male fertility in the final commercial F_1 hybrid.
IV. The F_1 hybrid seed harvested from the 'R' line is sold to farmers.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and IV
(C) I, II and III
(D) I and III

2022

132. Which statement regarding trait-specific cultivars is INCORRECT?
(A) Disease-resistant cultivars generally deploy specific R-genes that recognize pathogen effectors
(B) 'Golden Rice' is a bio-fortified variety genetically engineered to produce provitamin A (beta-carotene) in the endosperm
(C) High-yielding hybrid varieties intrinsically possess absolute immunity to all known viral and fungal pathogens
(D) Cultivars bred for drought tolerance frequently exhibit altered root architectures and osmotic adjustment

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2005

133. What is the cause and effect of crossing the male-sterile 'A' line exclusively with the 'B' maintainer line?
(A) The progeny remains identical to the 'A' line and retains male sterility, enabling propagation of the female parent line.
(B) The progeny regains full male fertility and exhibits high levels of heterosis and vegetative vigor in the field.
(C) The progeny undergoes rapid spontaneous mutations, generating highly diverse morpho-physiological traits.
(D) The progeny seeds fail to germinate under standard conditions due to extreme genomic incompatibility.

2002

134. All of the following are examples of specifically bio-fortified crop varieties released for enhanced nutrition EXCEPT which one?
(A) CR Dhan 310 (High protein rice)
(B) Pusa Mustard 30 (Low erucic acid)
(C) Bhu Sona (High beta-carotene sweet potato)
(D) Sharbati Sonora (High yield wheat)

2003

135. When comparing an improved open-pollinated variety (OPV) to an F_1 hybrid, what represents a distinct operational difference for the farmer?
(A) OPV seeds must be purchased fresh every year, while hybrid seeds can be saved and replanted indefinitely with no vigor loss.
(B) F_1 hybrid saved seed exhibits genetic segregation and major vigor loss in the F_2 generation, requiring annual seed purchase.
(C) OPVs guarantee absolute morphological and phenological uniformity in plant height and maturity compared to F_1 hybrids.
(D) Hybrids possess physiological pathways that completely eliminate the need for synthetic nitrogen fertilizer inputs.

2021

136. What is the approximate average nitrogen use efficiency (NUE) for lowland flooded rice in India?
(A) 10 to 15%
(B) 30 to 40%
(C) 60 to 70%
(D) 85 to 95%

2019

137. How is Agronomic Efficiency (AE) of an applied fertilizer mathematically defined?
(A) $\frac{\text{Total dry biomass of the treated plot}}{\text{Total volume of water transpired during growth}}$
(B) $\frac{\text{Total nutrient up take in the fertilized plot}}{\text{Total quantity of nutrients applied to soil}}$
(C) $\frac{\text{Economic yield of the harvested crop}}{\text{Total crop growth duration measure din calendar days}}$
(D) $\frac{\text{Yield of fertilized plot} - \text{Yield of control plot}}{\text{Quantity of fertilizer nutrient applied}}$

2013

138. Which concept accurately describes the standard nutrient uptake pattern in determinant annual crops like wheat or maize?
(A) Uptake is slow initially, accelerates during grand growth, and plateaus as the crop approaches maturity.
(B) Nutrient uptake follows a strictly linear, constant rate from the initial seedling emergence to final harvest.
(C) The plant absorbs the vast majority of its nutrient requirements during the final two weeks of grain filling.
(D) Active nutrient absorption from the soil ceases entirely once the first reproductive floral bud is initiated.

2010

139. Which statement correctly identifies a classic crop-specific nutrient deficiency symptom?
(A) Interveinal chlorosis on the youngest, uppermost leaves is the primary symptom of mobile nutrients like nitrogen.
(B) A distinct V-shaped chlorosis from the tip of older leaves is the classic symptom of nitrogen deficiency in maize.
(C) Dark green foliage with distinct purplish margins on the older leaves indicates acute calcium deficiency in crops.
(D) Necrotic spots along the margins of newly emerging leaves specifically indicate severe zinc deficiency in plants.

2002

140. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R).
Assertion (A): Band placement of phosphatic fertilizers below the seed is highly recommended compared to surface broadcasting.
Reason (R): Phosphorus is highly immobile in the soil and is prone to rapid fixation; placing it near the root zone maximizes early uptake.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2024

141. Which statement INCORRECTLY describes the behavior and deficiency symptoms of potassium in plants?
(A) Potassium plays a massive structural role, forming the rigid backbone of the cell wall pectin
(B) Potassium deficiency typically manifests as marginal necrosis or "scorching" on the older leaves
(C) It is highly mobile within the plant tissue, translocating from older to younger growing points under stress
(D) It is fundamentally involved in stomatal regulation and the maintenance of cell turgor

2008

142. What is the primary cause and effect of ammonia volatilization in fertilizer management?
(A) Deep placement of nitrate-based fertilizers causes them to evaporate instantly upon coming into contact with moist soil.
(B) The active presence of nitrifying soil bacteria directly transforms applied urea into inert dinitrogen gas molecules.
(C) Surface-applied urea on alkaline soils without incorporation volatilizes as ammonia gas, causing severe nitrogen loss.
(D) The use of advanced sulfur-coated urea formulations dramatically accelerates the immediate release of ammonia gas.

2024

143. All of the following elements are classified agronomically as essential micronutrients EXCEPT which one?
(A) Zinc
(B) Molybdenum

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2017

99. When comparing silage and hay making, which condition dictates the preference for silage over hay?
(A) Cloudy, rainy, or highly unpredictable weather during the harvest period
(B) High prevailing summer temperatures coupled with exceptionally low atmospheric humidity
(C) Standard cultivation of very thin-stemmed forage grasses like Cynodon dactylon
(D) The logistical need to transport the preserved fodder over very long commercial distances

2009

100. Which of the following is the primary active alkaloid found in the roots of Ashwagandha (Withania somnifera)?
(A) Morphine
(B) Scopolamine
(C) Quinine
(D) Withaferin-A

2024

101. How is the extraction of essential oils via steam distillation academically defined?
(A) The aggressive physical pressing of raw plant material to squeeze out lipophilic essential oils
(B) Volatilizing plant oils with steam, followed by condensation and water separation
(C) Soaking plant material in chemical hexane to dissolve all organic compounds, followed by evaporation
(D) Controlled burning of plant material and capturing the resulting fragrant smoke in a lipid matrix

2016

102. Which concept generally governs the alkaloid accumulation phase in medicinal root crops?
(A) Alkaloids reach their absolute maximum concentration during the early succulent seedling stage
(B) Excessive nitrogen fertilization linearly increases target secondary metabolite production indefinitely
(C) Alkaloid accumulation peaks as the plant reaches physiological maturity
(D) Active alkaloids are completely flushed out of the roots into the surrounding soil following heavy irrigation

2015

103. Which statement correctly describes a key cultivation requirement for Mentha (Mint) species?
(A) They require highly arid, un-irrigated conditions to maximize oil yield
(B) Mentha requires highly acidic soils with a pH around 4.5
(C) Harvesting is strictly done during the winter dormancy period
(D) The crop is primarily propagated through underground stolons or suckers

2019

104. Consider the following combinations of medicinal plants and their primarily utilized economic parts:
I. Isabgol (Plantago ovata) - Seed husk
II. Senna (Cassia angustifolia) - Leaves and pods
III. Sarpagandha (Rauvolfia serpentina) - Flowers
Which of the above combinations is/are INCORRECT?
(A) III only
(B) I and II
(C) II only
(D) I and III

2001

105. Which statement regarding the harvesting of Isabgol (Psyllium) is INCORRECT?
(A) The crop is generally harvested when the spikes turn brownish and the seeds are fully mature
(B) Harvesting must be delayed until the spikes are completely shattered to ensure maximum yield
(C) The economic product is the mucilaginous husk physically separated from the seed
(D) The crop is highly sensitive to unseasonal rainfall during the maturity stage

2023

106. What is the cause and effect of maintaining excessively high distillation temperatures and prolonged times during essential oil extraction?
(A) It causes thermal degradation of sensitive aromatic compounds, imparting a burnt odor to the oil.
(B) It extracts only the purest volatile fractions, leaving behind heavier, undesirable compounds.
(C) It completely prevents the hydrolysis of esters, maintaining the original chemical

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(A) It drastically shortens the vegetative phase but doubles the final individual grain weight.
(B) It causes pollen sterility and grain abortion, severely reducing the final crop yield.
(C) It forces the plant to produce a secondary set of taproots, fully compensating for the stress.
(D) It triggers physical vivipary, causing the developing grains to germinate on the panicle.

2018

152. All of the following are considered highly critical physiological stages requiring optimal irrigation in their respective crops EXCEPT which one?
(A) Active pod development phase in chickpea
(B) Direct flowering and pollination in sunflower
(C) Late physiological maturity and senescence in wheat
(D) Booting and panicle emergence phase in rice

2023

153. When comparing potential evapotranspiration (PET) to actual evapotranspiration (AET), under what condition does AET equal PET?
(A) When the soil moisture profile is depleted to the permanent wilting point.
(B) When atmospheric humidity is exceptionally high and wind speed is zero.
(C) When the crop canopy is completely defoliated by severe pest attacks.
(D) When soil moisture is abundant and non-limiting for a fully established canopy.

2016

154. What is the generally accepted critical period of crop-weed competition in direct-seeded rice?
(A) 0 to 10 days after sowing
(B) 15 to 45 days after sowing
(C) 60 to 90 days after sowing
(D) During the final grain-filling phase only

2007

155. How is a selective herbicide defined in modern weed management strategies?
(A) A compound that indiscriminately destroys all green vegetation and photosynthetic tissues on contact.
(B) A chemical that controls specific weed species without causing injury to the crop at recommended rates.
(C) A systemic toxicant designed to kill weed seeds buried deeper than fifteen centimeters in the soil.
(D) A natural plant extract formulated to repel grazing mammalian herbivores from agricultural fields.

2007

156. Which concept accurately describes the phenomenon of herbicide resistance in weed populations?
(A) The temporary physiological wilting of weed species caused by applying an insufficient dose of a chemical herbicide.
(B) The inherited ability of a weed biotype to survive a herbicide dose that would normally be lethal to the wild population.
(C) The rapid physical washing away of applied chemical active ingredients by intense rainfall immediately post-application.
(D) The premature chemical degradation and inactivation of herbicide compounds inside the spray tank prior to field delivery.

2017

157. Which statement correctly describes the nature of Phalaris minor in wheat cultivation?
(A) It is a competitive grassy annual weed that physically mimics wheat in its early vegetative growth stages.
(B) It is a persistent broadleaved perennial weed species that reproduces and spreads via deep subterranean rhizomes.
(C) It possesses complete immunity to physical and mechanical weeding due to the continuous release of toxic root exudates.
(D) It undergoes dormancy until the wheat crop reaches late development stages, germinating only during the grain dough stage.

2019

158. Consider the following statements regarding weed management practices:
I. Stale seedbed involves flushing weed seeds to germinate and destroying them before crop sowing.
II. Pre-emergence herbicides must be applied after the crop has fully developed its canopy.
III. Atrazine is widely used as a selective pre-emergence herbicide in maize and sugarcane.
IV. Parasitic weeds like Striga exclusively attack broadleaf crops like legumes.
Which of the above statements are INCORRECT?
(A) I and III
(B) II and IV
(C) I, II and IV
(D) II, III and IV

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altitudes. Crops domesticated in this region, such as specific potato species and quinoa, developed physiological adaptations to survive and yield under low-temperature regimes, high solar radiation, and limited moisture typical of alpine environments.

10. (B) Zea mays
Zea mays, commonly known as maize, is a classic example of a C_4 field crop. It possesses Kranz leaf anatomy and utilizes the dicarboxylic acid pathway for carbon fixation. This pathway minimizes photorespiration and enhances water-use efficiency under high temperatures. Conversely, rice, wheat, and soybean utilize the standard C_3 photosynthetic pathway.

11. (A) The biological response of plants to relative day and night lengths
Photoperiodism is the physiological reaction of plants to the relative duration of light and dark periods within a twenty-four-hour cycle. This biological timing mechanism regulates critical developmental transitions, most notably the induction of flowering. Crops are classified as short-day, long-day, or day-neutral depending on how they respond to these specific photoperiodic cues.

12. (C) To predict plant growth stages such as flowering and maturity
Growing Degree Days represent a temperature-derived index used to estimate the accumulation of heat units over time. Because plant development depends directly on ambient temperature rather than calendar days, calculating cumulative heat units allows agronomists to predict crop phenological stages, such as seedling emergence, flowering, and physiological maturity, with a high degree of accuracy.

13. (D) Stomata open at night for carbon fixation, closing during the day to save water
Crassulacean Acid Metabolism is an adaptation for extreme water conservation in arid-adapted plants like pineapple. CAM crops open their stomata during the cooler night hours to absorb and temporarily fix carbon dioxide into organic acids. During the hot daytime hours, the stomata remain closed to prevent transpiration, while stored carbon is released for photosynthesis.

14. (A) Both A and R are true and R is the correct explanation of A.
Thermoperiodism refers to the plant response to alternating day and night temperatures, which is critical for reproductive development in temperate crops. Fluctuations in diurnal temperatures regulate key enzyme systems and hormone concentrations necessary for floral induction. Consequently, both statements are factually correct, and the physiological mechanism described directly explains how temperature cycles govern reproduction.

15. (B) The first stable product of carbon fixation in C_3 plants is oxaloacetic acid
In C_3 plants, the primary carbon fixation step is catalyzed by the enzyme Rubisco, yielding the three-carbon molecule 3-phosphoglyceric acid as the first stable product. Oxaloacetic acid, a four-carbon compound, is instead the first stable product of carbon fixation in C_4 plants, where PEP carboxylase acts as the initial carbon-fixing enzyme in mesophyll cells.

16. (D) Reduced net carbon assimilation leading to lower dry matter yield
Under high temperatures and intense light, the oxygenase activity of Rubisco increases relative to its carboxylase activity. This triggers photorespiration, a wasteful metabolic pathway where C_3 plants consume oxygen and release previously fixed carbon dioxide. Consequently, net carbon assimilation decreases significantly, resulting in reduced biomass accumulation and overall lower dry matter yield.

17. (A) Wheat
Rice, soybean, and sorghum are classic short-day plants that require daily photoperiods shorter than a critical threshold to initiate flowering. Conversely, wheat is a long-day crop. It requires exposure to extended daylight periods and shorter nights to transition from vegetative growth to reproductive development, which ultimately regulates successful head emergence and grain production.

18. (C) They concentrate carbon dioxide around Rubisco to sustain photosynthesis under closed stomata
C_4 crops possess specialized Kranz leaf anatomy, allowing them to spatially separate carbon fixation. The enzyme PEP carboxylase initially captures carbon dioxide in mesophyll cells,

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(D) Gluten is formed by hydrating gliadin and glutenin, providing crucial elasticity and extensibility.

2022

167. Select the correct sequence of fiber quality indices evaluated in cotton, ranked loosely from physical dimension to physical strength:
(A) Micronaire, Staple length, Bundle strength
(B) Staple length, Micronaire, Bundle strength
(C) Bundle strength, Micronaire, Staple length
(D) Micronaire, Bundle strength, Staple length

2003

168. Which statement regarding the fatty acid profiles of oilseeds is INCORRECT?
(A) Sunflower oil is highly valued for its high concentration of polyunsaturated linoleic acid
(B) Groundnut oil contains significant amounts of oleic and linoleic acids
(C) Traditional rapeseed-mustard oil contains very low levels of erucic acid natively
(D) Safflower oil has one of the highest concentrations of linoleic acid among cultivated oilseeds

2017

169. What is the cause and effect of high gossypol content in standard cotton seed meals?
(A) It renders the raw meal highly nutritious and directly digestible for sensitive monogastric farm poultry.
(B) It extends the shelf life of the extracted oil by completely preventing lipid oxidation during storage.
(C) It alters the saturation levels, converting residual liquid oils into solid fats at standard room temperatures.
(D) It acts as a toxic polyphenolic compound, limiting the use of seed cake as feed for monogastric animals.

2010

170. All of the following are considered essential amino acids critically evaluated in cereal and pulse quality profiles EXCEPT which one?
(A) Glutamine
(B) Lysine
(C) Tryptophan
(D) Methionine

2023

171. In comparing the specific storage proteins of major cereals, which pair accurately contrasts maize and wheat?
(A) Maize primarily consists of structural globulins, while wheat consists of zein storage proteins.
(B) Maize predominantly contains zein, whereas wheat contains gluten (gliadin and glutenin proteins).
(C) Both crops are completely devoid of any prolamins, relying on water-soluble albumins for storage.
(D) Maize storage protein forms a highly cohesive, elastic dough matrix identical to wheat gluten.

2015

172. The visible formation of a distinct black layer at the base of the kernel is a definitive physiological maturity index for which crop?
(A) Wheat
(B) Maize
(C) Soybean
(D) Rice

2025

173. How is the physiological maturity of a grain crop formally defined in agronomy?
(A) The stage when seed dry matter accumulation stops and the vascular connection to the parent plant is severed.
(B) The physical stage characterized by the complete yellowing and desiccation of all foliar canopy tissues.
(C) The post-development stage when grain moisture drops below twelve percent, ensuring safe bulk storage.
(D) The early developmental stage during which the first open flowers begin to shed petals and form pods.

2010

174. Which concept describes the use of a Brix refractometer reading in sugarcane maturity assessment?
(A) It measures rind hardness across different internodes to determine structural readiness for harvesting.
(B) It quantifies the level of reducing sugars (glucose and fructose) which must be elevated prior to harvest.
(C) It estimates total soluble solids in the juice, with a reading of 18-20 typically indicating maturity.
(D) It determines the remaining volume of free water inside the storage parenchyma cells of the stalks.

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of highly expensive fossil diesel fuel or electricity to run fans.
(C) It causes complete thermal destruction of embryonic tissues, eliminating the germination viability of seeds.
(D) It dries the grain too rapidly, creating severe structural stress cracks and fissures in every kernel.

2018
190. What is the approximate starch content by weight in a standard mature maize kernel?
(A) 20 to 30%
(B) 40 to 50%
(C) 70 to 75%
(D) 90 to 95%

2013
191. How is bioethanol chemically defined within the context of agricultural industrial processing?
(A) An industrial alcohol synthesized from petroleum gas streams via catalytic hydration of ethylene.
(B) A highly toxic methanol-based derivative utilized strictly as an organic solvent for farm pesticides.
(C) A long-chain saturated fatty acid compound extracted from the seeds of industrial oilseed crops.
(D) Ethyl alcohol produced via yeast fermentation of sugars from crops like sugarcane or grain corn.

2012
192. Which concept outlines the industrial utilization of molasses?
(A) It is the primary high-purity, white crystallized sucrose product produced by the centrifugal refinery.
(B) It is the fibrous, woody residue left after crushing cane, burned to generate steam in factory boilers.
(C) It is a dark, viscous byproduct containing uncrystallized sugars used for distillery fermentation.
(D) It is the nutrient-rich filter press mud applied back to agricultural fields as a high-nitrogen manure.

2018
193. Which statement correctly identifies the major industrial application of bagasse?
(A) It is fermented under aerobic conditions using Acetobacter species to produce commercial vinegar.
(B) It is used as a boiler biofuel for electricity cogeneration and as a raw material for paper pulp.
(C) It is subjected to solvent extraction processes to retrieve high-value edible residual cooking oils.
(D) It is chemically cracked at high temperatures to serve as the base monomer for synthetic rubber.

NODIA

2024
194. Consider the following statements detailing value-added byproduct utilization:
I. Rice bran contains significant amounts of edible oil that can be extracted via solvent extraction.
II. Cottonseed hulls are entirely toxic and must be incinerated immediately.
III. Press mud from sugar mills is an excellent soil ameliorant containing organic matter and nutrients.
IV. Jute sticks left after retting are heavily used for making particle boards and fuel.
V. Wheat straw is industrially processed to extract pure crystalline sucrose.
Which of the above statements are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and V
(D) I, IV and V

2003
195. Which statement regarding the industrial wet milling of maize is INCORRECT?
(A) Wet milling is specifically designed to produce whole-grain cornmeal for direct baking
(B) The process begins by steeping the corn in water with sulfur dioxide to soften the kernel
(C) The process separates the kernel into its distinct anatomical parts: germ, hull, gluten, and starch
(D) The separated germ is highly valuable for the extraction of corn oil

2011
196. What is the cause and effect relationship determining bioethanol fermentation metrics?
(A) High initial ethanol levels stimulate yeast division, increasing cell populations and maximizing yield.
(B) Continuous, rapid aeration of tanks forces yeast to process sugars into ethanol instead of carbon dioxide.
(C) Accumulating ethanol eventually becomes

eliminate foliar pathogens.
(C) The rapid, high-temperature thermal burning of leaf margins to seal in volatile organic compounds and oils.
(D) A regulated drying process that removes moisture while developing desired leaf color, texture, and aroma.

2008
183. Which concept accurately describes the mechanics of deep-bed artificial drying of grains?
(A) Thermal energy is applied strictly to the top grain layer, relying on gravity to dry the remaining bottom layers.
(B) Forced heated air is passed upward through bulk grain, creating a drying zone that moves from bottom to top.
(C) Grains are submerged in high-temperature vegetable oils to rapidly boil away internal moisture contents.
(D) Grains are maintained in a high vacuum environment at freezing temperatures to sublimate internal water molecules.

2002
184. Which statement correctly describes the standard milling recovery percentage for paddy (rice)?
(A) Milling of harvested paddy typically yields ninety percent head white rice and ten percent residual hull.
(B) The milling process yields exactly fifty percent structural bran and fifty percent polished white starch.
(C) Standard milling yields roughly 65-70% total milled rice, with the remainder being outer husk and bran.
(D) Industrial milling recovers exactly one hundred percent of the initial grain weight by adding steam.

2008
185. Consider the following statements regarding post-harvest handling:
I. Parboiling of rice gelatinizes the starch, increasing milling recovery and preserving B vitamins.
II. Tea fermentation is an anaerobic bacterial process that ferments the sugars into alcohol.
III. High moisture storage of grains drastically accelerates respiration and heat build-up.
IV. Flue-curing of Virginia tobacco relies entirely on direct exposure to open smoke and flames.
Which of the above statements are INCORRECT?
(A) I and III
(B) II and IV
(C) I, II and IV
(D) II, III and IV

2013
186. Which statement regarding the processing of black tea is INCORRECT?
(A) The critical "fermentation" step is a microbial process requiring the inoculation of external yeast cultures.
(B) Withering is the initial step designed to remove surface and internal moisture from freshly plucked leaves.
(C) Rolling physically disrupts the cellular structure of leaves, initiating the enzymatic oxidation process.
(D) Firing terminates the enzymatic oxidation reactions, locking in the final desired tea flavor profile.

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2018
187. What is the specific cause and effect of storing groundnut pods at moisture levels exceeding 9% in poorly ventilated conditions?
(A) The pods undergo rapid viviparous germination, producing highly vigorous but unusable crop seedlings.
(B) High moisture favors Aspergillus flavus growth, leading to dangerous kernel contamination with aflatoxins.
(C) The lipids stored inside the cotyledons undergo immediate saponification, converting into sodium soaps.
(D) The outer fibrous shells physically lignify and harden into an impenetrable layer resembling dense wood.

2006
188. All of the following crops exhibit distinct climacteric behavior (experiencing a sudden surge in respiration during post-harvest ripening) EXCEPT which one?
(A) Banana
(B) Citrus
(C) Tomato
(D) Mango

2010
189. In comparing traditional sun drying to mechanical heated-air drying of grains, what is a primary limitation of sun drying?
(A) It depends on weather conditions and exposes grain to contamination by environmental dust, birds, and pests.
(B) It demands the continuous consumption

2014

175. Which statement correctly identifies the physiological moisture limits generally accepted for the harvesting of cereal grains?

(A) Harvesting should only commence once the standing grain moisture has dropped to exactly five percent.

(B) Harvesting is delayed until night, allowing the grains to re-hydrate to forty percent moisture from dew.

(C) Crops are harvested when grain moisture exceeds sixty percent to maximize total wet weight and volume.

(D) Crops mature at 30-35% moisture but are harvested at 18-22% to avoid mechanical damage to grains.

2019

176. Consider the following statements detailing specific crop maturity indices:

I. In groundnut, maturity is indicated when the inside of the pod shell turns dark brown.

II. In cotton, maturity is judged by the dropping of all vegetative leaves prior to boll bursting.

III. In potato, maturity is indicated by the haulms turning yellow and falling over, accompanied by tuber skin hardening.

Which of the above statements are correct?

(A) I and II

(B) I and III

(C) II and III

(D) I only

2021

177. Which statement regarding visual indicators of crop maturity is INCORRECT?

(A) Yellowing of the peduncle just below the ear is a highly reliable visual indicator in certain small cereal grains.

(B) Drying and dropping of lower leaves guarantees that the seed has achieved maximum dry weight accumulation.

(C) The transition of pod color from green to brown or black is used to assess maturity in several grain pulses.

(D) The natural bursting of mature bolls and exposure of inner white fluff is the definitive harvest index for cotton.

2011

178. What is a primary cause and effect of severely delaying the harvesting of a crop like soybean well past its physiological maturity?

(A) It leads to a significant increase in the final concentration of high-quality oil stored within seed cotyledons.

(B) It stimulates the senesced stems to initiate a secondary vegetative flush and produce additional flowers.

(C) It causes mature seeds to germinate internally while still in the pod, increasing their overall physical size.

(D) It leads to severe pod shattering, which results in massive and irreversible pre-harvest grain loss in the field.

2001

179. All of the following are physical or chemical maturity indices utilized in agronomy EXCEPT which one?

(A) Acid value of the extracted oil in the field

(B) Kernel hardness determined by biting or crushing

(C) Brix ratio between the top and bottom internodes

(D) Visual formation of the black layer

2006

180. When comparing physiological maturity to harvest maturity, which distinction is accurate?

(A) Harvest maturity typically occurs several weeks before true physiological maturity is reached by the plant.

(B) Physiological maturity applies to forage crops, whereas harvest maturity applies only to human grain crops.

(C) Physiological maturity marks peak dry weight, whereas harvest maturity occurs later when grains are dry enough.

(D) There is no scientific distinction between the two terms; they define identical grain moisture percentages.

2014

181. What is the universally accepted maximum safe moisture content for the long-term bulk storage of most cereal grains?

(A) 4 to 6%

(B) 10 to 12%

(C) 16 to 18%

(D) 22 to 24%

2018

182. How is the process of curing defined in the post-harvest management of tobacco?

(A) A physical, mechanical shredding of harvested green leaves carried out immediately after field collection.

(B) The soaking of fresh leaves in highly concentrated aqueous salt solutions to

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toxic to yeast cells, halting fermentation at tolerance limits.
(D) Dropping mash temperatures to freezing levels dramatically accelerates starch hydrolysis into simple sugars.

2015
197. All of the following are significant industrial uses of extracted plant starches EXCEPT which one?
(A) Direct formulation of highly concentrated nitrogen fertilizers
(B) Sizing agent in the textile and paper industries
(C) Raw material for the production of high-fructose corn syrup
(D) Manufacturing of biodegradable plastics (bioplastics)

2024
198. When comparing first-generation and second-generation biofuels, what fundamental distinction defines second-generation production?
(A) First-generation fuels are biodiesel from oilseeds, whereas second-generation fuels are bioethanol from wood.
(B) First-generation depends on direct solar capture, whereas second-generation depends on wind power systems.
(C) First-generation uses lignocellulose, whereas second-generation relies on edible vegetable seed oils.
(D) First-generation uses food crops, whereas second-generation relies on non-food lignocellulosic biomass.

2001
199. In crop production economics, what specific expenses are comprehensively included in the definition of Cost A_2?
(A) Cost A_1 plus the imputed value of family labor
(B) Cost A_1 plus rent paid for leased-in land
(C) The total cost of cultivation minus the cost of chemical fertilizers
(D) The absolute total value of the gross return

2018
200. How is the benefit-cost $(B{:}\,C)$ ratio strictly defined mathematically?
(A) The quotient of total variable cultivation costs divided by the sum of fixed capital expenses.
(B) The difference calculated when net financial returns are subtracted from total gross crop returns.
(C) The ratio of the present value of gross returns to the present value of total project costs.
(D) The physical volume of crop yield in kilograms divided by total monetary production costs in rupees.

2018
201. Which concept accurately describes the calculation of Cost C (or C_2) in Indian agricultural economics?
(A) It represents solely the cash and out-of-pocket input expenses incurred by the operating farmer.
(B) It is a specialized economic metric that measures only the imputed value of unpaid family labor.
(C) It is calculated by multiplying the base Cost A_1 by the total physical cultivated farm acreage.
(D) It is a comprehensive cost covering actual expenses, rental values, interest, and family labor.

2013
202. Which statement correctly distinguishes between gross returns and net returns?
(A) Gross return is total income from all sales, whereas net return is gross return minus total cultivation cost.
(B) Gross return represents net profit remaining after income taxes are paid, ignoring seasonal crop input costs.
(C) Net return is a metric that consistently exceeds gross return whenever market prices rise above averages.
(D) Gross return covers only byproduct revenues, whereas net return covers the primary harvested grain yields.

2005
203. Arrange the following standard economic cost concepts from the narrowest (least inclusive) to the broadest (most inclusive) calculation:
1. Cost C
2. Cost A_1
3. Cost B
(A) 3, 2, 1
(B) 2, 3, 1
(C) 1, 2, 3
(D) 2, 1, 3

2024
204. Which statement regarding imputed costs in farm economics is INCORRECT?

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(A) Imputed costs represent the estimated value of resources owned and provided by the farmer for which no actual cash payment is made
(B) The imputed wage of family labor is generally excluded from the calculation of Cost C
(C) Imputed rental value of owned land is heavily factored into comprehensive cost analysis
(D) Ignoring imputed costs often leads to a severe overestimation of the true economic profitability of a farm enterprise

2023
205. What is the mathematical cause and effect of government subsidies on fertilizers on a farmer's operational $B{:}\,C$ ratio?
(A) Subsidies reduce out-of-pocket input costs without lowering gross returns, increasing the farmer's B:C ratio.
(B) Subsidies artificially inflate total cultivation costs, driving the final calculated B:C ratio well below 1.0.
(C) Subsidies proportionally lower both input costs and market returns, leaving the B:C ratio perfectly unchanged.
(D) Subsidies mandate a reduction in the harvest market price of crops, immediately cutting the B:C ratio in half.

2011
206. All of the following are generally classified as variable costs in crop production EXCEPT which one?
(A) Total monetary cost of certified commercial seeds
(B) Daily wages paid to casual hired laborers for harvest
(C) Depreciation charges on machinery and farm buildings
(D) Expenses incurred on chemical pesticides and herbicides

2016
207. In comparing Cost B_1 and Cost B_2, which specific component is added to Cost B_1 to arrive at Cost B_2?
(A) The exact cash cost of purchased diesel fuel for machinery
(B) The total imputed monetary value of unpaid family labor
(C) The combined cost of all organic and inorganic fertilizers
(D) The rental value of owned land plus rent paid for leased land

2019
208. Among the following field crops, which generally exhibits the highest total water requirement (consumptive use) over its complete growing season?
(A) Wheat
(B) Groundnut
(C) Sugarcane
(D) Sorghum

2007
209. Which statement correctly interprets Liebig's Law of the Minimum in crop agronomy?
(A) Yields increase linearly as long as any single nutrient is applied in massive agricultural excess.
(B) Growth is dictated not by total resources, but by the scarcest resource acting as a limiting factor.
(C) Minimum air temperatures define the absolute maximum genetic yield potential of all tropical crops.
(D) Soil moisture is the sole abiotic factor that can completely limit physiological plant development.

2019
210. Identify the strictly correct pairing of the specific field crop with its dominant root system architecture:
(A) Pearl millet – Deep taproot system
(B) Chickpea – Shallow fibrous root system
(C) Maize – Tuberous storage root system
(D) Cotton – Prominent deep taproot system

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ANSWERS

1. (A) Mesoamerica
Nikolai Vavilov identified Mesoamerica, specifically the region encompassing southern Mexico and parts of Central America, as the primary center of origin for maize. This geographic area exhibits the highest genetic diversity of wild relatives, particularly teosinte, which is the direct ancestor of modern maize. Archaeological evidence also supports this region as the early site of domestication.

2. (C) A geographic region where a crop exhibits the greatest genetic variation
In agricultural botany and crop science, a center of diversity represents a distinct geographic territory where a specific plant species displays its highest level of genetic variation. These regions contain a dense concentration of closely related wild progenitors, diverse landraces, and unique alleles, making them invaluable genetic reservoirs for crop breeding programs and biodiversity conservation efforts worldwide.

3. (A) By offering localized areas of rich wild diversity for germplasm collection
Microcenters are small, localized areas within broader centers of diversity where intense evolutionary activity and plant speciation occur. These concentrated pockets host rich assemblies of wild crop relatives and highly variable landraces. Plant breeders target these specific geographical niches to collect diverse germplasm containing beneficial genes for pest resistance, disease tolerance, and environmental adaptability.

4. (D) A primary center is the area of initial domestication, while a secondary center develops diversity later
A primary center of origin is the original geographical territory where a crop species was first domesticated from its wild ancestors. Conversely, a secondary center of origin develops when a crop is introduced to a new region, undergoes extensive hybridization or natural selection, and generates high levels of genetic variation and diverse landraces over a subsequent period.

5. (B) I and III
The Near East center is widely recognized as the primary origin of major temperate crops, including wheat and barley. Additionally, the Mediterranean center is historically known for the diversification of various forage crops, such as white clover. Conversely, the primary center of origin for soybean is located within the East Asian or Chinese center, not the Indian center.

NODIA

6. (C) Wheat adaptation is restricted exclusively to temperate climatic zones
Wheat is a highly adaptable cereal crop grown across a wide range of climates globally. Although it is primarily associated with temperate areas, its cultivation is not restricted to those zones. Wheat is successfully grown in subtropical, Mediterranean, and even high-altitude tropical regions. It thrives in diverse environments, provided temperature and moisture requirements are met.

7. (D) Selection for day-neutral or long-day tuberization traits
Wild potato ancestors from the Andean region require short-day photoperiods to initiate tuberization. When introduced to Northern Europe's long summer days, these plants produced heavy foliage but delayed tuber formation until late autumn. Successful European adaptation required selective breeding and natural adaptation to identify genotypes capable of tuberization under long-day or day-neutral photoperiod conditions.

8. (A) Sorghum
Potato, cassava, and peanut have their primary centers of origin in South America, where they evolved and were first domesticated. Conversely, sorghum is indigenous to Africa, with its primary center of genetic diversity situated in the northeastern African region. Sorghum was subsequently distributed to other semi-arid and tropical areas of the world for cultivation.

9. (B) Adaptation to cool, high-altitude climates
The Andean center of origin is characterized by rugged mountainous topography with cooler temperatures, frost risks, and thin soils at high

2011

159. Which statement INCORRECTLY characterizes pre-emergence herbicide application?

(A) It requires adequate soil moisture to ensure the herbicide spreads and forms an active barrier in the soil

(B) It aims to kill emerging weed seedlings as their shoots or roots pass through the treated soil layer

(C) Pendimethalin is a classic example of a widely used pre-emergence herbicide

(D) The chemical must be applied directly to the weed foliage for effective absorption

2006

160. What is the cause and effect relationship between a severe infestation of Orobanche (Broomrape) and a tobacco crop?

(A) The weed roots physically wrap around and strangle upper tobacco stems, blocking crucial sunlight absorption.

(B) The weed releases toxic volatile organic compounds that cause permanent and irreversible stomatal closure.

(C) The weed attaches to the tobacco roots as an obligate parasite, draining water and nutrients to stunt the host.

(D) The weed outcompetes tobacco primarily by developing a taller canopy that completely shades out the crop below.

2025

161. All of the following chemicals act as selective herbicides under appropriate agronomic use EXCEPT which one?

(A) 2,4-D

(B) Glyphosate

(C) Metsulfuron-methyl

(D) Pendimethalin

2016

162. When comparing the control of grassy versus broadleaf weeds, why is 2,4-D frequently used in wheat?

(A) It strictly targets and eradicates only the grassy weed species Phalaris minor in wheat fields.

(B) It forms a physical, protective waxy barrier over wheat leaves that blocks fungal pathogen entry.

(C) It acts as an organic nitrogen foliar fertilizer for wheat while actively dehydrating adjacent weeds.

(D) Grassy growing points are protected and resist 2,4-D, whereas broadleaf weeds undergo lethal growth.

2022

163. What is the agronomic significance of reducing the erucic acid content in improved mustard varieties?

(A) High erucic acid is linked to myocardial lipidosis and poor human cardiovascular health.

(B) High erucic acid causes the cooking oil to vaporize and split violently during shallow frying.

(C) Low erucic acid improves the physical and chemical lubrication properties of industrial oils.

(D) Reducing erucic acid concentrations increases the total percentage of oil extracted by weight.

2010

164. In the assessment of cotton fiber quality, what exactly does the micronaire value measure?

(A) The absolute staple length of the longest 2.5% of fibers within a representative sample.

(B) The physical tensile force required to snap or break a standard bundle of cotton fibers.

(C) The combined measure of fiber fineness and maturity determined through air permeability.

(D) The gravimetric percentage of organic and inorganic foreign trash mixed within raw lint.

2024

165. Which conceptual classification accounts for the dominant protein fraction found in most pulse crops (grain legumes)?

(A) Globulins

(B) Prolamins

(C) Glutelins

(D) Albumins

2021

166. Which statement correctly identifies the functional property of gluten in wheat quality assessment?

(A) Gluten is a complex carbohydrate starch that dictates the physical density of mature wheat grains.

(B) High gluten strength is highly sought after in wheat varieties milled for soft biscuit manufacture.

(C) Gluten acts as a hydrophobic barrier that prevents the flour from absorbing water during dough mixing.

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transporting it to bundle sheath cells where it is concentrated around Rubisco. This mechanism suppresses photorespiration and allows C_4 plants to maintain high photosynthetic rates even when stomata close to conserve water.

19. (B) 6.0 to 7.5
Wheat plants grow best in slightly acidic to neutral soils, with an optimal pH range of 6.0 to 7.5. Within this range, essential plant nutrients like nitrogen, phosphorus, and potassium are highly bioavailable. Extreme soil acidity or alkalinity restricts nutrient uptake, damages root systems, and increases susceptibility to toxicities from metals like aluminum.

20. (D) The soil's capacity to conduct current, indicating soluble salt concentration
Electrical conductivity in soil analysis measures the ability of a soil solution to conduct an electrical current. Because dissolved salts increase the conductivity of water, this parameter serves as an accurate, indirect indicator of the total concentration of soluble salts present in the soil. It is crucial for identifying saline soils and managing crop salinity risks.

21. (B) By determining the exchangeable sodium percentage replaced by calcium
To reclaim alkaline or sodic soils, the gypsum requirement must be determined. This calculation is based on measuring the exchangeable sodium percentage on the soil colloid complex. Gypsum provides soluble calcium ions that physically displace harmful exchangeable sodium ions from the clay particles, facilitating their leaching out of the root zone and restoring proper soil structure.

22. (C) Barley and cotton possess high tolerance to elevated soil EC
Crops vary significantly in their physiological tolerance to soil salinity. Barley and cotton are classified as highly salt-tolerant crops capable of maintaining acceptable yields even under elevated electrical conductivity conditions. Conversely, pulse crops are highly sensitive to salinity, and rice is particularly vulnerable during the early seedling stage, which limits its growth in saline soils.

23. (D) P-2, Q-4, R-1, S-3
Different crops possess distinct soil pH adaptations. Tea is highly acidophilic, thriving in highly acidic soils with a pH of 4.5 to 5.5. Barley exhibits high tolerance to mildly alkaline conditions. Potato performs best in moderately acidic to neutral soils, while alfalfa requires neutral to slightly alkaline soils for optimal root development and symbiotic nitrogen fixation.

24. (A) A higher soil pH generally increases the availability of micronutrients like iron and zinc
Soil pH significantly influences the chemical availability of essential plant nutrients. As soil pH increases, particularly above neutral levels, the solubility of most micronutrients, including iron, zinc, manganese, and copper, decreases because they form insoluble hydroxides. Consequently, higher soil pH limits their availability, frequently inducing nutrient deficiencies in crops grown in alkaline soils.

25. (B) Dispersion of clay particles by high exchangeable sodium
Alkali or sodic soils contain high concentrations of exchangeable sodium ions on clay surfaces. Because sodium has a large hydrated radius and low charge density, it causes clay particles to disperse and repel one another. This dispersion breaks down stable soil aggregates, clogging macro-pores and creating a dense, structureless layer that severely restricts water infiltration and aeration.

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26. (B) Rice
Most field crops are highly sensitive to waterlogged, anaerobic soil conditions because roots require oxygen for respiration. Rice is a notable exception due to specialized internal adaptations. It possesses aerenchyma tissues, which are continuous air channels in the stems and roots. This anatomical feature allows oxygen to transport from the atmosphere down to the root system.

27. (A) Black surface spots caused by dissolved organic matter
Sodic soils are characterized by high pH and a high exchangeable sodium percentage, which leads to the dispersion of clay and organic matter. This dispersed organic matter dissolves in the highly alkaline soil solution and rises to the surface via capillary action. As the water evaporates, it leaves behind a dark, black crust on the soil surface.

this critical developmental stage reduces the quality and yield of medicinal extracts.

103. (D) The crop is primarily propagated through underground stolons or suckers
Mentha species, cultivated widely for essential oils like menthol, rely primarily on vegetative methods for successful field propagation. Since commercial mint varieties rarely produce viable botanical seeds, crops are established using underground vegetative structures, specifically stolons or suckers. Planting healthy, active stolons ensures rapid, uniform stand establishment and maintains clonal genetic purity across the field.

104. (A) III only
Isabgol is cultivated for its seed husk, which contains valuable mucilage, and Senna is grown for its laxative-rich leaves and pods. Conversely, Sarpagandha, academically classified as Rauvolfia serpentina, is primarily valued for its roots, which contain active alkaloids like reserpine. The flowers of Sarpagandha are not utilized as the primary commercial economic product.

105. (B) Harvesting must be delayed until the spikes are completely shattered to ensure maximum yield
Isabgol spikes are highly susceptible to seed shattering at maturity. If harvesting is delayed until the spikes completely shatter, a significant proportion of the seeds will fall onto the ground and be lost. To maximize economic yield, harvesting must be performed slightly before total dryness, typically when the spikes turn a brownish color.

106. (A) It causes thermal degradation of sensitive aromatic compounds, imparting a burnt odor to the oil.
Maintaining excessively high temperatures and prolonged distillation times during essential oil extraction leads to the thermal degradation of sensitive volatile organic compounds. This overheating breaks down delicate esters and monoterpenes, causing chemical polymerization and oxidation. As a direct result, the chemical profile is altered, which introduces an undesirable burnt or scorched odor, reducing the oil's overall quality.

107. (B) Menthol
Alkaloids are naturally occurring organic nitrogenous compounds that exert prominent physiological actions on humans. Examples include reserpine, atropine, and vincristine, which serve vital medicinal and economic functions. Menthol, however, is classified as a monoterpene alcohol rather than an alkaloid. It is derived from peppermint oil and is primarily valued for its cooling, aromatic, and flavoring properties.

108. (B) It passes steam through the material without boiling, reducing thermal degradation and preventing scorching.
Steam distillation is highly preferred over hydro-distillation because the plant material does not come into direct contact with boiling water. Instead, dry steam is generated externally and passed directly through the biomass. This operational setup prevents localized overheating and scorching of the plant tissues, significantly reducing thermal degradation of the heat-sensitive volatile constituents within the essential oils.

109. (C) 14 to 16%
Amaranth is a nutrient-dense pseudo-cereal that stands out for its superior nutritional profile compared to traditional cereal grains. It typically contains an average protein content of fourteen to sixteen percent. This protein is exceptionally high-quality because it has an optimal amino acid balance, particularly rich in lysine, which is normally the limiting amino acid in true cereals.

110. (C) A non-grass dicot plant whose seeds are used and consumed in the same manner as true cereal grains
In botanical agronomy, pseudo-cereals are formally defined as non-grass, broad-leaved dicotyledonous plants that produce starchy seeds. Unlike true cereals, which belong to the monocotyledonous Poaceae family, pseudo-cereals produce seeds that can be milled into flour and cooked in the same way as grains. Common examples include amaranth, buckwheat, and quinoa species.

111. (D) Their genetic resilience to severe abiotic stresses, poor soil fertility, and highly erratic rainfall
Under-utilized crops and minor millets possess extreme adaptation characteristics that allow them to thrive in marginal lands. These crops have evolved robust genetic mechanisms that provide resilience against harsh abiotic pressures

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grow rapidly and are ready for field transplanting within eleven to fourteen days.

38. (C) Cultivating direct-seeded rice in well-drained, non-puddled, and non-flooded soils
Aerobic rice cultivation is a production system where specially adapted rice varieties are direct-seeded into well-drained, non-puddled, and non-flooded fields. Unlike traditional paddy rice systems that require continuous water submergence, aerobic rice is managed like upland crops like wheat or maize, utilizing targeted irrigation to maintain soil moisture without standing surface water.

39. (D) Widely spacing young, single seedlings to promote maximum tillering
The System of Rice Intensification focuses on optimizing plant growth by reducing competition and managing resources. A core principle of this methodology is transplanting very young, single seedlings per hill at wide, square spacings. This open planting geometry provides ample space, light, and nutrients, which promotes robust root systems and maximizes productive tillering capacity.

40. (A) Primary tillers emerge from main shoot nodes, and secondary tillers from primary ones
Tillering is a critical vegetative growth stage in cereal crops where auxiliary buds produce lateral branches. The developmental sequence begins when primary tillers emerge directly from the lower nodes of the main shoot. Subsequently, secondary tillers arise from the basal nodes of those primary tillers, creating a highly organized branching structure that determines final panicle density.

41. (B) II and IV
In the System of Rice Intensification, fields are not kept continuously flooded; instead, alternate wetting and drying regimes are applied. Additionally, aerobic rice is designed to conserve water, meaning it requires significantly less water than puddled transplanted rice. Puddling does destroy soil structure to reduce percolation, and Dapog seedlings are raised without soil.

42. (B) Wheat requires continuous standing water from tillering to physiological maturity
Unlike lowland paddy rice, wheat is an upland crop that does not tolerate prolonged waterlogged soils or standing water. Continuous standing water from tillering to physiological maturity induces anaerobic conditions in the root zone, severely restricting oxygen uptake and nutrient absorption. Instead, wheat requires targeted irrigation at specific critical growth stages like crown root initiation.

43. (A) It forms an impermeable soil layer to reduce deep water percolation
Puddling involves churning water-saturated soil to break down stable aggregates and disperse clay particles. This mechanical action destroys the soil's structure, creating a dense, compacted subsurface layer known as a plow pan. This impermeable layer restricts downward water movement, reducing percolation losses and allowing standing water to be maintained on the field surface.

44. (C) Transplanting 30-day-old seedlings to ensure field survival
The System of Rice Intensification promotes the transplanting of extremely young seedlings, typically eight to twelve days old, when they have only two leaves. Transplanting older, thirty-day-old seedlings is avoided because it induces transplant shock and severely restricts the plant's subsequent tillering capacity, which contradicts the core physiological principles of the methodology.

45. (D) Higher water-use efficiency but lower overall yield potential than flooded rice
Cultivating aerobic rice significantly reduces water inputs, which yields a higher water-use efficiency compared to traditional flooded rice systems. However, because aerobic soils restrict nutrient mobility, increase weed competition, and lack the yield-boosting benefits of continuous water submergence, this water savings comes at the trade-off of a lower overall grain yield potential.

46. (C) Silica accumulation and heavy waxy bloom on the leaf epidermis
Sorghum displays exceptional drought tolerance due to specific anatomical features on its leaves. It accumulates significant silica deposits in the epidermal cells and develops a thick, waxy bloom over its leaf surface. This waxy layer acts as a physical barrier that drastically reduces non-stomatal transpiration and reflects excess solar radiation, conserving plant moisture during dry periods.

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47. (B) Accumulating cellular solutes to maintain turgor at low water potentials
Osmotic adjustment is an active physiological process where millet crops accumulate compatible cellular solutes, such as proline, soluble sugars, and potassium ions, within their cytoplasm. This solute accumulation lowers the cellular osmotic potential, allowing the plant to draw water from dry soils and maintain crucial cell turgor and metabolic functions even under severe water stress conditions.

48. (D) They possess the C_4 pathway, minimizing photorespiration and saving water
Millets are C_4 photosynthetic plants that utilize PEP carboxylase to initially fix carbon dioxide in mesophyll cells. This highly efficient carbon-concentrating mechanism allows them to keep their stomatal pores partially closed during hot, dry daytime hours to conserve water. Because they minimize wasteful photorespiration, they produce high amounts of biomass per unit of transpired water.

49. (A) A strong tillering ability that compensates for sparse plant populations
Pearl millet is a highly resilient crop characterized by an exceptionally robust tillering capacity. This physiological trait allows the plant to produce multiple grain-bearing stalks from a single seed. Consequently, in rainfed environments where seedling emergence can be erratic and sparse, the crop's strong tillering ability compensates for low plant densities to sustain grain yields.

50. (A) Both A and R are true and R is the correct explanation of A.
Young sorghum plants, particularly those under drought stress or at early growth stages, contain high concentrations of the cyanogenic glycoside dhurrin in their vegetative tissues. When livestock consume this young foliage, enzymatic breakdown in the rumen releases highly toxic hydrocyanic or prussic acid, which rapidly inhibits cellular respiration, making raw, immature sorghum forage highly dangerous for cattle.

51. (A) It is predominantly cultivated as a direct-seeded, rainfed crop without nursery preparation
While finger millet can be direct-seeded in rainfed systems, it is predominantly and highly successfully cultivated using transplanted methods in major growing regions. Farmers raise seedlings in dedicated nurseries and transplant them to well-prepared fields. This practice ensures uniform stand establishment, facilitates efficient weed control, and significantly maximizes grain yield compared to direct broad-casting.

52. (D) Loss of turgor in bulliform cells rolls leaves inward to reduce exposed area and transpiration
Sorghum leaves contain specialized, large epidermal cells called bulliform cells. Under severe moisture stress, these cells lose their turgor pressure and dry out rapidly. This loss of cellular turgor causes the leaf blade to roll inward. Rolling reduces the total leaf surface area exposed to direct sunlight, which lowers transpiration and conserves internal plant moisture.

53. (B) Karnal bunt
Pearl millet production is heavily affected by fungal diseases like downy mildew (green ear disease), ergot, and smut, which devastate the grain heads and foliage. Conversely, Karnal bunt is a highly specific, quarantine-significant fungal disease caused by Tilletia indica that infects wheat crops, causing a fishy odor and kernel damage, but does not infect pearl millet.

NODIA

54. (C) Sorghum can remain dormant during drought and resume growth when moisture is available
Sorghum possesses a highly unique physiological survival mechanism that allows it to enter a state of semi-dormancy during prolonged periods of severe water deficit. Growth stops completely to preserve energy and prevent dehydration. When rainfall or irrigation occurs, sorghum plants quickly reactivate their physiological processes and resume active vegetative and reproductive development, a trait lacking in maize.

55. (D) Bradyrhizobium japonicum
Soybean requires a highly specific group of symbiotic nitrogen-fixing bacteria to form functional root nodules. Bradyrhizobium japonicum is the slow-growing bacterial species commercially utilized for soybean seed inoculation. Treating seeds with this inoculant ensures effective root nodulation and efficient biological nitrogen fixation, supporting high grain protein yields without heavy synthetic nitrogen fertilizers.

56. (A) Plucking apical buds of young plants to promote lateral branching
Nipping is a critical cultural operation in chickpea agronomy where the apical buds of young plants are plucked or removed about thirty to forty days after sowing. By removing the apical dominance, this practice stimulates the development of lateral branches, which increases the total number of flowers, pods, and seeds per plant, maximizing crop yield.

57. (B) Symbiotic bacteria in nodules convert atmospheric nitrogen into ammonia
Biological nitrogen fixation in pulse crops is a symbiotic process where soil bacteria of the genus Rhizobium infect plant roots to form nodules. Within these nodules, the bacteria utilize the nitrogenase enzyme complex to split gaseous atmospheric nitrogen, converting it directly into ammonia. The plant absorbs this ammonia for protein synthesis, while supplying carbon carbohydrates to the bacteria.

58. (B) It binds oxygen, maintaining a microaerobic nodule environment
The nitrogenase enzyme, which catalyzes biological nitrogen fixation, is highly sensitive to oxygen and is irreversibly inactivated by it. Leghemoglobin is an iron-bearing oxygen-binding protein in root nodules that regulates free oxygen levels. It binds free oxygen to maintain a strict microaerobic environment for nitrogenase activity, while delivering sufficient oxygen for bacterial respiration.

59. (A) P-2, Q-4, R-1, S-3
Leguminous crops form host-specific symbiotic associations with distinct Rhizobium species. Chickpea root nodulation is specifically mediated by Mesorhizobium ciceri. Alfalfa or lucerne requires inoculation with Rhizobium meliloti. Field pea forms effective nodules with Rhizobium leguminosarum, and soybean requires the slow-growing bacterial species Bradyrhizobium japonicum to successfully initiate biological nitrogen fixation in agricultural systems.

60. (C) Phosphorus application heavily depresses nodule formation and nitrogen fixation
Phosphorus is a critical macronutrient in pulse crop nutrition because it serves as the primary energy currency via ATP. High energy levels are essential for the energy-intensive process of biological nitrogen fixation. Rather than depressing nodule formation, adequate phosphorus applications significantly enhance root elongation, stimulate rapid nodule development, and boost total nitrogen-fixing efficiency in legumes.

61. (D) Larvae feed on the developing flowers and young pods, leading to a drastic reduction in seed yield
The gram pod borer, Helicoverpa armigera, is a major insect pest of chickpea. Early larval infestations target reproductive tissues, where they feed extensively on emerging flower buds, open flowers, and developing green pods. By destroying these structures, the pest directly prevents seed set and pod development, resulting in severe economic damage and lower seed yields.

62. (C) French bean (Phaseolus vulgaris)
French bean is a major grain legume that acts as a notable exception to typical nodulating pulses. Under natural field conditions in India, French bean plants generally lack effective root nodulation due to a lack of compatible native Rhizobium strains and inherent physiological plant limitations. Consequently, this crop requires external nitrogen fertilizer inputs to achieve high yields.

63. (B) Mungbean exhibits epigeal, and pigeonpea exhibits hypogeal germination
Pulse crops display distinct seed germination behaviors. Mungbean undergoes epigeal germination, where rapid hypocotyl elongation pushes the cotyledons above the soil surface. Conversely, pigeonpea exhibits hypogeal germination, where the epicotyl elongates while the cotyledons remain buried within the soil profile. Understanding these physical growth habits is essential for managing planting depths and weed control.

64. (B) 40 to 45 days
In bunch-type groundnut varieties, pegging is a critical physiological stage that begins roughly forty to forty-five days after sowing. Following successful fertilization of the flowers, the ovary elongates to form a specialized, needle-like structure called a peg. This peg grows downward, penetrating the soil surface where it subsequently develops into a subterranean pod.

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28. (C) Germination percentage
The theoretical plant population per hectare is calculated purely based on spatial crop geometry. This mathematical formula requires the total land area of one hectare, the spacing between adjacent planting rows, and the spacing between individual plants within those rows. While germination percentage is essential for determining actual seed rates, it does not alter the theoretical population calculation.

29. (D) Planting crops into unprepared soil leaving at least 30 percent residue cover
Zero tillage, or no-till farming, is a conservation practice where crops are sown directly into soil that has not been prepared or disturbed by primary or secondary tillage operations. This technique uses specialized seeders to slice through crop residues, placing seeds directly into the soil. Agronomically, it requires maintaining at least thirty percent residue cover.

30. (C) A lower real value requires increasing the seed rate to achieve the target stand
The real value of seed is determined by multiplying its purity percentage by its germination percentage. This value represents the actual proportion of viable, clean seeds in a batch. If the real value is low, a larger total quantity of bulk seed must be sown per unit area to compensate for non-viable seeds and establish the target plant population.

31. (B) Coleoptile length is the primary determinant of maximum safe sowing depth in cereals
In cereal crops, the coleoptile is the protective sheath that covers the emerging shoot as it pushes upward through the soil. The genetic length of this coleoptile dictates the maximum depth at which seeds can be safely sown. Sowing deeper than the coleoptile's maximum length prevents the seedling from reaching the surface, causing high mortality.

32. (D) Primary plowing, Harrowing, Planking, Sowing
Conventional seedbed preparation follows a logical sequence of field operations. It begins with primary plowing to invert and break deep soil layers. This is followed by harrowing to pulverize large clods and destroy emerging weeds. Planking is then performed to level and compact the soil surface, creating an ideal, firm seedbed ready for seed sowing.

33. (A) Higher plant populations always result in a linear increase in per-plant economic yield
As plant populations increase, resource competition for light, water, and soil nutrients intensifies among individual plants. This competitive pressure reduces the growth rate and per-plant economic yield. Therefore, the relationship between plant population and per-plant yield is not linear; instead, individual plant performance decreases as planting density exceeds the optimal carrying capacity of the field.

34. (C) Destruction of the hardpan for deeper root penetration and moisture extraction
Subsoiling is a deep tillage practice that targets compacted subsurface layers, commonly known as hardpans, without turning over the topsoil. Breaking this dense layer restores soil macroporosity, allowing plant roots to penetrate deeper into the profile. This enhances the crop's ability to extract water and nutrients from lower soil horizons, particularly during dry spells.

35. (A) Complete and immediate eradication of perennial weed populations
Conservation tillage reduces soil disturbance and maintains surface crop residues, which helps control soil erosion, conserve moisture, and lower fuel costs. However, because it minimizes mechanical soil inversion, weed seeds are not buried deeply. This often leads to increased weed pressure, particularly from persistent perennial weeds, which are difficult to eradicate without mechanical tillage.

36. (D) It drains excess water safely and conserves moisture during dry spells
Vertisols have high clay content and are prone to waterlogging during heavy rains and severe cracking during dry periods. The broad bed furrow system structures the field into raised beds separated by parallel furrows. This configuration allows excess water to drain safely through the furrows during heavy rains, while conserving critical root-zone moisture during dry spells.

37. (A) 11 to 14 days
The Dapog method is a quick nursery technique originating in the Philippines where rice seedlings are raised on a non-soil surface, such as concrete or plastic sheets. Because seedlings do not draw nutrients from soil, they rely entirely on endosperm food reserves. Consequently, they

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secrete enzymes that break down the complex pectins, hemicelluloses, and gums binding the fibers together, facilitating easy physical separation of intact bast fibers.

75. (A) To remove leaves before harvest to reduce lint trash and improve picking efficiency
In mechanized cotton harvesting, chemical defoliants are applied to the crop shortly before picking. These chemicals trigger the natural senescence and shedding of green leaves. Removing the foliage prevents green leaves from staining the white fibers during harvest, lowers the volume of leaf trash in the harvested lint, and significantly improves the efficiency of mechanical pickers.

76. (C) Planting a non-Bt cotton refuge alongside Bt cotton to delay insect resistance
To manage insect resistance to the Bacillus thuringiensis endotoxin, regulations in India require planting a structured refuge of non-Bt cotton alongside Bt cotton fields. This refuge provides a critical habitat for susceptible pests, such as the pink bollworm, allowing them to survive and mate with any rare resistant pests emerging from Bt fields, thereby delaying resistance.

77. (A) Both A and R are true and R is the correct explanation of A.
In jute processing, ribboning involves peeling the raw bark containing fibers off green stems before retting. This advanced technique serves as an effective alternative to whole-plant retting. Because only the fiber-rich ribbons are submerged, the process requires significantly less water and time, while preventing over-retting, which yields higher quality fiber with improved tensile strength.

78. (C) Shedding of squares is an abnormal symptom caused solely by insect pest attacks
In cotton physiology, the shedding of squares and young bolls is a complex process governed by both biotic and abiotic stresses. While insect pests like bollworms trigger shedding, significant leaf and bud drop is also driven by physiological factors. Severe moisture stress, waterlogging, nitrogen deficiencies, and low light intensities alter internal auxin balances, inducing natural abscission.

79. (B) It causes vegetative overgrowth, delaying maturity and increasing sucking pests
Applying excessive nitrogen fertilizer during the vegetative phase of cotton shifts the plant's metabolic balance. It stimulates aggressive, succulent vegetative overgrowth at the expense of reproductive boll development, which delays overall crop maturity. Furthermore, this succulent tissue contains high soluble nitrogen levels, which attracts damaging sap-sucking pests like jassids, whiteflies, and aphids.

80. (D) Cotton
Bast fibers are structural plant fibers extracted from the phloem or inner bark of specific dicotyledonous stems, such as jute, mesta, and sunnhemp, using biological retting. Conversely, cotton is commercially classified as a surface fiber. It develops as unicellular seed hairs on the epidermal surface of developing cotton seeds within the ripening boll structure.

81. (A) Greater tolerance to drought and marginal soils
Desi cotton species, such as Gossypium arboreum and Gossypium herbaceum, have evolved unique physiological traits that make them highly resilient. They possess a deep, extensive root system and low transpiration rates, providing superior adaptation and tolerance to severe drought conditions and marginal, low-fertility soils compared to the high-yielding but input-sensitive American cotton.

82. (B) 35,000 to 40,000 setts
For conventional flat planting of sugarcane, achieving an optimal crop stand requires a standard seed rate of thirty-five thousand to forty thousand three-budded setts per hectare. This quantity translates to approximately seventy-five to eighty thousand buds per hectare. This seeding density ensures uniform germination, rapid early tillering, and sufficient millable canes at harvest.

83. (A) Tying mature canes with dry leaves to prevent lodging
Sugarcane stalks grow tall and heavy as they accumulate sugar towards maturity, which makes them highly susceptible to lodging under strong winds. Propping is a cultural practice where adjacent sugarcane stalks are physically tied together using dry leaves and trash. This provides

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65. (A) To support the stem physically, preventing lodging from heavy heads and wind
Sunflower crops develop large, heavy heads at maturity and possess a relatively shallow root system, making them highly susceptible to wind-induced lodging. Earthing-up involves piling soil around the base of the plant stem. This creates a supportive physical barrier, anchoring the stem securely to the ground to prevent plants from falling over during strong winds.

66. (C) By foliar spraying dilute NAA at the pre-flowering or early flowering stage
Excessive flower and pod drop is a major physiological constraint that limits productivity in pulses and oilseed crops. This shedding is often driven by internal hormonal imbalances. Foliar application of naphthalene acetic acid, a synthetic auxin, at the pre-flowering or early flowering stage helps regulate abscission zones, preventing premature flower drop and boosting final pod retention.

67. (A) Pre-flowering (rosette) and early siliqua formation
Indian mustard requires adequate soil moisture at specific physiological stages to maximize oil and seed yields. The pre-flowering rosette stage and the early siliqua formation stage are highly sensitive to water stress. Moisture deficits during these critical periods severely restrict lateral branching, reduce flower numbers, and limit pod filling, which leads to substantial crop yield losses.

68. (D) I, III and V
In groundnut cultivation, pegging requires soft, loose soil so the developing peg can easily penetrate the surface. Earthing-up is critical to support plants and ensure developing pegs enter the soil, away from direct sunlight. Calcium deficiency directly results in unfilled pods, or pops, which is corrected by applying gypsum to supply calcium rather than nitrogen.

69. (B) The broadcasting seed rate is 15–20 kg per hectare
Sesame seeds are exceptionally small and lightweight. Consequently, the recommended broadcasting seed rate for sesame is very low, typically ranging from four to five kilograms per hectare. Sowing fifteen to twenty kilograms per hectare is excessively high, resulting in overcrowded plant stands, intense resource competition, high seedling mortality, and severely reduced per-plant capsule yields.

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70. (C) Gypsum supplies localized calcium directly to the pod, preventing unfilled pops
Groundnut pegs and developing pods absorb essential calcium directly from the surrounding soil solution rather than drawing it from the main root system. Applying gypsum at the pegging stage ensures a highly concentrated supply of soluble calcium in the shallow podding zone. This localized calcium absorption is vital for proper embryo development, effectively preventing unfilled pods, known as pops.

71. (A) Indian mustard
Indian mustard, a member of the Brassicaceae family, requires significant amounts of sulfur to support its physiological growth. Sulfur is a key constituent of glucosinolates, which are secondary metabolites responsible for the characteristic pungent oil aroma. Applying sulfur directly enhances glucosinolate synthesis, increases seed oil content, and improves overall mustard yields.

72. (A) Safflower relies on a deep taproot for moisture, while sunflower needs frequent irrigation
Safflower and sunflower manage soil moisture stress using different rooting systems. Safflower is exceptionally drought-tolerant because it develops a deep, robust taproot system that penetrates down into the soil to extract water from lower horizons. Conversely, sunflower possesses a shallower root system, which makes it more reliant on frequent surface rainfall or targeted irrigations to sustain yields.

73. (B) $\dfrac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$
Ginning outturn is a crucial quality and yield parameter in cotton processing. It represents the proportion of clean lint fiber obtained from raw harvested seed cotton after removing the seeds. GOT is calculated by dividing the total weight of extracted lint by the total weight of the starting seed cotton material, and multiplying by one hundred.

74. (B) Microbial breakdown of pectins and gums binding fibers to the stem core
Retting is a biological extraction process used in jute production to separate fiber bundles from the woody core. Submerging stalks in slow-moving water allows native anaerobic bacteria and fungi to proliferate. These microorganisms

total yield. Conversely, very frequent cuts provide high-quality forage but low total biomass. Optimizing the cutting interval ensures an intermediate harvest time, balancing high cumulative dry matter yield with acceptable protein levels and fiber digestibility.

94. (C) Reducing moisture to 12–15% rapidly without causing leaf loss
Hay curing aims to dry freshly cut green forage quickly to prevent spoilage while preserving essential nutrients. Effective curing requires reducing the total moisture content to twelve to fifteen percent. This moisture level inhibits microbial activity during storage. The drying process must be managed carefully to avoid brittle stems and leaves, which can cause leaf shatter.

95. (A) 2, 4, 1, 3
Silage fermentation progresses through a sequence of distinct biological phases. It begins with the aerobic respiration phase, where oxygen trapped in the forage is consumed. Once anaerobic conditions are established, short-lived acetic acid bacteria initiate fermentation. This is followed by the active lactic acid production phase, which stabilizes and preserves the forage material.

96. (D) HCN toxicity in sorghum increases significantly as the crop approaches full maturity
HCN toxicity in sorghum does not increase with plant age; rather, it is highly concentrated in very young vegetative shoots and drought-stressed seedlings. As the sorghum crop matures and approaches the boot stage, the total concentration of the cyanogenic glycoside dhurrin decreases significantly, making the mature fodder safe for general animal feeding.

97. (A) Lactic acid drops pH below 4.2, inhibiting putrefactive bacteria to preserve forage
During the ensiling process, the proliferation of anaerobic lactic acid bacteria leads to the rapid fermentation of water-soluble carbohydrates. The resulting accumulation of lactic acid drops the silage pH below 4.2. This highly acidic environment inhibits the growth of harmful clostridia and other putrefactive bacteria, effectively preserving the forage nutrients and preventing spoilage during long-term storage.

98. (C) Applying massive doses of nitrogen fertilizer just before harvesting
Applying massive doses of nitrogen fertilizer just before harvesting does not mitigate anti-nutritional factors; instead, it significantly increases the accumulation of toxic nitrates and cyanogenic glycosides like dhurrin in young forage crops. Safe management practices include harvesting at proper maturity stages, ensiling, and wilting the cut forage to lower toxicity risks.

99. (A) Cloudy, rainy, or highly unpredictable weather during the harvest period
Hay making requires several consecutive days of dry, sunny weather to reduce forage moisture content below fifteen percent without spoilage. If the harvest period is characterized by cloudy, rainy, or unpredictable weather, field drying becomes impossible. Under these humid conditions, farmers prefer silage making because it relies on airtight fermentation and does not require field drying.

100. (D) Withaferin-A
Ashwagandha, academically classified as Withania somnifera, is a highly valued medicinal plant. The roots of this crop accumulate diverse secondary metabolites, most notably a class of steroidal lactones known as withanolides. Among these, Withaferin-A is identified as the primary active therapeutic compound responsible for the plant's adaptogenic and medicinal properties in pharmaceutical applications.

101. (B) Volatilizing plant oils with steam, followed by condensation and water separation
Steam distillation is a widely utilized physical extraction process for isolating volatile essential oils from aromatic plant materials. During this process, pressurized steam passes through the plant tissues, causing the target essential oils to volatilize. This mixture is then cooled in a condenser, causing it to liquefy, allowing the oil to be separated from water.

102. (C) Alkaloid accumulation peaks as the plant reaches physiological maturity
In medicinal root crops, the biosynthesis and accumulation of active secondary metabolites are closely linked to the plant's phenological development. Alkaloid concentrations typically follow an upward trend, reaching their peak level as the crop approaches full physiological maturity. Harvesting too early or delaying past

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structural support and stability, preventing the heavy canes from falling over onto the ground.

84. (D) Eradicating seed-borne pathogens like ratoon stunting and grassy shoot diseases
Hot water treatment, where sugarcane setts are submerged in water at fifty degrees Celsius for two hours, is an effective phytosanitary measure. The heat penetrates the sett tissues, selectively destroying thermal-sensitive pathogens like bacteria and phytoplasmas. This process eradicates systemic, seed-borne diseases such as ratoon stunting and grassy shoot, ensuring clean, disease-free starting material.

85. (B) It lowers seed requirements while ensuring higher survival and better crop geometry
The Sustainable Sugarcane Initiative utilizes single-bud seedlings raised in nurseries rather than standard three-budded setts. This methodology significantly reduces the volume of cane seed material needed per hectare. It ensures a high seedling survival rate, establishes uniform crop geometry, and optimizes resource-use efficiency, which promotes robust tillering and increases final cane yields.

86. (C) P-2, Q-4, R-1, S-3
Sugarcane cultivation involves highly specific field operations. Blind hoeing is performed after planting but before shoot emergence to break crusts and control early weeds. Earthing-up is carried out during the formative phase to promote root growth and provide drainage. Wrapping is done during the monsoon to prevent lodging, and trash mulching conserves moisture during dry periods.

87. (D) It is highly sensitive to soil salinity and requires completely salt-free soils
Sugarbeet is not highly sensitive to salt; rather, it is recognized as a highly salt-tolerant crop, especially during its vegetative growth phase. It can be successfully cultivated in saline soils where other sensitive crops fail. While seedling emergence is moderately sensitive to salinity, mature sugarbeet plants can tolerate elevated electrical conductivity levels without significant yield reduction.

88. (A) It suppresses weed emergence and conserves soil moisture to improve ratoon vigor
Applying a thick layer of dry sugarcane trash as mulch in a ratoon crop serves multiple agronomic purposes. The mulch acts as a physical barrier that blocks solar radiation, preventing weed seed germination and suppressing weed growth. Additionally, it reduces evaporation from the soil surface, conserving critical moisture and promoting early ratoon sprout vigor.

89. (B) Tasseling phase
Sugarcane development is divided into four distinct vegetative growth phases: the germination phase, the formative phase, the grand growth phase, and the ripening or maturity phase. Conversely, tasseling refers to the emergence of the male inflorescence in maize crops, which is a developmental stage that does not occur in sugarcane.

90. (B) Fluff represents true botanical seed from flowers, while setts are vegetative cuttings
Sugarcane is commercially propagated using setts, which are stem cuttings containing vegetative buds. Conversely, fluff refers to the tiny, wind-dispersed true botanical seeds produced in the sugarcane flowers or tassels. Fluff is highly heterogeneous and is utilized exclusively in plant breeding and hybridization programs, rather than for commercial crop production.

91. (A) Below 200 ppm on a dry weight basis
Sorghum plants can contain toxic levels of hydrocyanic acid, particularly in young shoots or drought-stressed foliage. For safe livestock consumption, the total HCN concentration must remain below two hundred parts per million on a dry weight basis. Feeding forage that exceeds this safe threshold can cause rapid, lethal cyanide poisoning in ruminants.

92. (C) Anaerobic fermentation of sugars to lactic acid, dropping pH for preservation
The primary objective of silage making is to preserve high-moisture green forage in an airtight environment. This anaerobic condition stimulates native lactic acid bacteria to ferment soluble sugars into lactic acid. The accumulation of lactic acid drops the forage pH below 4.2, which prevents the growth of putrefactive bacteria and molds, preserving nutritional quality.

93. (D) An intermediate cutting interval balances high biomass yield with protein and digestibility
In multi-cut fodder crops, structural fibers like lignin increase with plant maturity, reducing digestibility and protein content while increasing

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such as prolonged droughts, extreme heat, and low soil fertility. Consequently, they produce reliable yields where high-input commercial monocultures fail due to water scarcity.

112. (C) The seeds must be washed or milled to remove bitter saponins present on the outer layer of the seed coat
Quinoa grains naturally produce a bitter, soapy compound called saponin on the outer layer of their seed coat. Saponins act as a natural defense mechanism against pests, birds, and pathogens. Before the grains can be consumed by humans, they must undergo extensive washing, scrubbing, or mechanical milling to completely remove these unpalatable and mildly toxic compounds.

113. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Buckwheat is highly adapted to mountainous, high-altitude regions because it possesses a very short growth cycle, often maturing in seventy to ninety days. This rapid development allows the crop to successfully complete its life cycle during the short frost-free windows of mountain summers. Therefore, both the physiological cultivation choice and the developmental explanation are completely accurate.

114. (D) They lack any complex carbohydrates, consisting almost entirely of simple sugars
Minor millets are highly regarded for their outstanding nutritional characteristics. They are gluten-free, rich in dietary fiber, and contain high levels of essential minerals like iron and calcium. Structurally, they are composed primarily of complex carbohydrates, especially slow-digesting resistant starch. This composition results in a low glycemic index, rather than consisting of simple sugars.

115. (A) It allows the crop to escape terminal drought by finishing its life cycle before soil moisture is depleted
Early maturity is a crucial evolutionary adaptation in under-utilized crops growing in arid or semi-arid zones. By accelerating their vegetative growth and transitioning quickly to reproduction, these plants complete seed production before the dry season starts. This mechanism allows them to escape terminal drought by finishing their life cycle before available soil water is depleted.

116. (C) Triticale
Pseudo-cereals are dicotyledonous plants that produce starch-rich seeds, such as grain amaranth, buckwheat, and quinoa. Unlike these species, triticale is not a pseudo-cereal. It is a man-made cereal hybrid developed in the late nineteenth century by crossing wheat, which belongs to the genus Triticum, with rye, which belongs to the genus Secale.

117. (A) They lack gluten-forming proteins entirely, causing poor dough elasticity and low leavening capacity.
The baking performance of pseudo-cereals like quinoa or amaranth is chemically distinct from wheat because they lack gluten-forming proteins, namely gliadin and glutenin. Without these proteins, dough cannot form a cohesive, elastic, and extensible network that traps carbon dioxide gas during fermentation. Consequently, pseudo-cereal flours yield products with poor dough elasticity and low leavening.

118. (D) To establish timber plantations by letting farmers grow food crops alongside tree seedlings in the early years.
The Taungya agroforestry system was established in Myanmar during the mid-nineteenth century to cost-effectively reforest degraded areas with high-value timber like teak. Landless farmers were allowed to cultivate agricultural food crops between young tree seedlings during the initial years. This dual approach provided subsistence food for farmers while ensuring successful, cheap establishment of timber plantations.

119. (B) The deliberate, concurrent growing of agricultural crops and forest trees on the same unit of land.
An agri-silviculture system is a fundamental division of agroforestry. It is characterized by the deliberate, systematic, and concurrent cultivation of agricultural crops and forest trees on the same unit of land. This spatial or temporal integration optimizes land-use efficiency, improves soil fertility through leaf litter, and provides farmers with both food and timber products.

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120. (C) The release of biochemicals by one plant that inhibits the germination, growth, or survival of adjacent species.
Allelopathy describes the chemical interactions between co-cultivated plant species in ecosystems. It occurs when a plant releases specialized

pattern over the life cycle. Uptake is slow during early seedling establishment, accelerates rapidly during the vegetative grand growth phase as biomass expands, and finally slows or plateaus as nutrients are remobilized within the plant to support grain filling during maturity.

139. (B) A distinct V-shaped chlorosis from the tip of older leaves is the classic symptom of nitrogen deficiency in maize.
Nitrogen is highly mobile within plant tissues, meaning deficiency symptoms appear first on older leaves as the plant redirects nutrients to new growth. In maize, this manifests as a highly characteristic V-shaped chlorosis that starts at the leaf tip and progresses inward along the midrib, leaving the margins green until the deficiency worsens.

140. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Phosphorus is highly immobile in the soil solution because it readily binds with iron, aluminum, or calcium minerals to form insoluble complexes. Band placement below and beside the seed is highly recommended because it minimizes soil contact and places the phosphorus directly in the early root development zone, maximizing nutrient uptake and supporting early root growth.

141. (A) Potassium plays a massive structural role, forming the rigid backbone of the cell wall pectin
Potassium is not a structural component of plant cells and does not form cell wall pectin, which is actually the role of calcium. Instead, potassium exists as a highly mobile free ion in plant fluids. It regulates osmotic potential, drives stomatal opening and closing, maintains cell turgor, activates enzymatic pathways, and translocates rapidly to support new growth.

142. (C) Surface-applied urea on alkaline soils without incorporation volatilizes as ammonia gas, causing severe nitrogen loss.
Applying urea directly to alkaline soil surfaces without physical incorporation leads to rapid hydrolysis by the urease enzyme. This chemical reaction elevates the local pH around the fertilizer granules, promoting the conversion of ammonium ions into volatile ammonia gas. Consequently, substantial quantities of nitrogen escape into the atmosphere, which significantly reduces overall fertilizer efficiency.

143. (D) Magnesium
Micronutrients are elements required by crops in very small quantities. Zinc, molybdenum, and boron are classified as essential micronutrients due to their trace metabolic roles. Magnesium, however, is a secondary macronutrient required in much larger amounts because it forms the central atom of the chlorophyll molecule and acts as a structural cofactor for enzymatic systems.

144. (C) PE measures yield increase per unit nutrient absorbed, whereas RE measures the percentage of applied nutrient absorbed.
In agricultural systems, Physiological Efficiency measures the increase in economic yield per unit of nutrient absorbed by the crop from the soil. In contrast, Recovery Efficiency evaluates the percentage of the applied fertilizer nutrient that is successfully taken up by the plant. Both metrics provide distinct, critical perspectives on crop utilization and fertilizer placement.

145. (B) 21 to 25 days
Crown Root Initiation is the most critical irrigation stage in wheat cultivation, occurring twenty-one to twenty-five days after sowing. During this developmental phase, crown roots begin to form just below the soil surface. Any water stress at this stage severely restricts root system establishment and reduces tiller development, leading to permanent, irreversible yield declines.

146. (D) The ratio of actual crop evapotranspiration (ETc) to the reference crop evapotranspiration (ETo).
The crop coefficient represents a crucial dimensionless factor used to calculate water requirements. It is defined as the ratio of actual crop evapotranspiration under optimal conditions to reference crop evapotranspiration. This value changes dynamically throughout the growing season based on crop growth stage, leaf area index, canopy development, and soil surface wetness.

147. (A) $CU =$ Transpiration + Evaporation + Water required form etabolic processes
Consumptive Use of water by a crop represents the total volume of water consumed in plant growth. It is mathematically calculated as the sum of water lost through transpiration from leaf surfaces, water evaporated from the surrounding soil surface, and the tiny amount of water

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129. (B) A maternally inherited mitochondrial trait prevents functional pollen production, enabling controlled cross-pollination.
Cytoplasmic Male Sterility is a maternally inherited physiological trait caused by mitochondrial gene dysfunctions that prevent the development of functional pollen grains. Because the female reproductive organs remain fully fertile, these plants can only produce seeds when cross-pollinated. This biological mechanism eliminates the labor-intensive need for manual emasculation during commercial hybrid seed production.

130. (D) It was a semi-dwarf, rust-resistant variety key to India's Green Revolution success.
Kalyansona was a highly successful, landmark semi-dwarf wheat variety introduced in India during the late 1960s. Developed from Mexican breeding lines, this cultivar possessed excellent rust resistance and responded exceptionally well to fertilizer inputs. It played a major historical role in accelerating domestic wheat production, serving as a pillar of the Green Revolution.

131. (C) I, II and III
In the three-line hybrid seed production system, the A-line is male sterile and serves as the female parent. The B-line is the isogenic male-fertile maintainer used to multiply the A-line. The R-line is the restorer line containing nuclear genes that restore fertility in the final commercial hybrid seed, which is harvested specifically from the A-line.

132. (C) High-yielding hybrid varieties intrinsically possess absolute immunity to all known viral and fungal pathogens
While disease-resistant cultivars deploy specific resistance genes, and bio-fortified Golden Rice produces beta-carotene, high-yielding hybrid varieties do not possess complete immunity to all pathogens. Hybrids are bred primarily for vigor and high yield potential, and they remain vulnerable to diverse strains of fungi, bacteria, and viruses unless specific resistance genes are actively bred into them.

133. (A) The progeny remains identical to the 'A' line and retains male sterility, enabling propagation of the female parent line.
Crossing the male-sterile A-line with its isogenic male-fertile maintainer B-line produces progeny that are genetic copies of the A-line. This occurs because the B-line lacks fertility-restoring nuclear genes, meaning the maternally inherited cytoplasmic male sterility is fully preserved. This cross is essential for propagating and multiplying the female parent line for hybrid seed production.

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134. (D) Sharbati Sonora (High yield wheat)
While CR Dhan 310, Pusa Mustard 30, and Bhu Sona are modern cultivars bred specifically for nutrient enhancement, Sharbati Sonora is not a bio-fortified variety. It is an amber-grained mutant wheat variety developed in India during the Green Revolution through radiation mutation breeding of Sonora 64, selected primarily for grain color and high yields.

135. (B) F_1 hybrid saved seed exhibits genetic segregation and major vigor loss in the F_2 generation, requiring annual seed purchase.
Farmers can save and replant seeds from improved open-pollinated varieties for several seasons without significant loss in yield. However, F_1 hybrid seeds cannot be saved for subsequent planting because the F_2 generation undergoes dramatic genetic segregation. This segregation leads to a massive loss of hybrid vigor, resulting in highly uneven crop growth and low yields.

136. (B) 30 to 40%
In the lowland flooded rice cultivation systems of India, nitrogen use efficiency typically ranges from thirty to forty percent. This low efficiency is due to rapid nitrogen losses occurring in anaerobic soil conditions. Applied nitrogen fertilizers are highly prone to multiple loss pathways, including surface runoff, leaching, ammonia volatilization, and denitrification in the waterlogged soil environment.

137. (D) $\dfrac{\text{Yield of fertilized plot} - \text{Yield of control plot}}{\text{Quantity of fertilizer nutrient applied}}$
Agronomic Efficiency is a key metric used to evaluate fertilizer use. It is mathematically defined as the increase in economic crop yield per unit of nutrient applied. The calculation subtracts the yield of the unfertilized control plot from the yield of the fertilized plot, and then divides that value by the total quantity of nutrient applied.

138. (A) Uptake is slow initially, accelerates during grand growth, and plateaus as the crop approaches maturity.
In determinant annual crops such as wheat or maize, nutrient absorption follows a sigmoidal

five percent. However, harvesting at this high moisture content is avoided because wet grains are soft and highly susceptible to mechanical damage during threshing. Consequently, crops are left to field-dry until moisture drops to eighteen to twenty-two percent before harvesting.

176. (B) I and III
In groundnuts, maturity is indicated by the internal darkening of the pod shell to a dark brown color. In potatoes, maturity is marked by the yellowing of the foliage, accompanied by the hardening of the tuber skin. Cotton maturity is determined by boll splitting rather than complete leaf drop, making statements I and III correct.

177. (B) Drying and dropping of lower leaves guarantees that the seed has achieved maximum dry weight accumulation.
Visual cues are often used to estimate crop maturity, such as peduncle yellowing in wheat or pod color changes in legumes. However, the drying and dropping of lower leaves does not guarantee physiological maturity. Leaf senescence can be triggered prematurely by factors like moisture stress, nutrient deficiencies, or foliar diseases rather than grain development.

178. (D) It leads to severe pod shattering, which results in massive and irreversible pre-harvest grain loss in the field.
Delaying the harvest of soybean past its physiological maturity has serious consequences. As the mature pods dry in the field under fluctuating temperature and relative humidity, they lose elasticity and build up internal stress. This dry state causes the pods to split open, leading to severe shattering and irreversible pre-harvest grain loss.

179. (A) Acid value of the extracted oil in the field
Agronomists assess crop maturity using various physical and chemical indices. These include kernel hardness, Brix ratios in sugarcane, and the visual formation of a kernel black layer. However, the acid value of extracted oil is not used as a maturity index in the field. Instead, it is a post-harvest quality indicator of oil rancidity.

180. (C) Physiological maturity marks peak dry weight, whereas harvest maturity occurs later when grains are dry enough.
Physiological maturity and harvest maturity occur at different times. Physiological maturity marks the point when the plant stops accumulating dry matter in the seed, which usually happens at a high grain moisture content. Harvest maturity occurs later, after the grain has field-dried sufficiently to allow safe mechanical harvesting, handling, and long-term storage.

181. (B) 10 to 12%
For long-term bulk storage, most cereal grains must be dried to a safe moisture content of ten to twelve percent. Storing grains above this range accelerates seed respiration and promotes mold growth, which causes heating and spoilage. Maintaining this safe range preserves seed viability, prevents fungal damage, and protects the grains from insect infestations.

182. (D) A regulated drying process that removes moisture while developing desired leaf color, texture, and aroma.
In tobacco processing, curing is a carefully regulated post-harvest drying process. It goes beyond simple water removal to facilitate critical biochemical changes inside the harvested leaves. This slow, controlled drying breaks down green chlorophyll, converts starches into sugars, and develops the specific leaf color, texture, and aroma required for commercial tobacco products.

183. (B) Forced heated air is passed upward through bulk grain, creating a drying zone that moves from bottom to top.
Deep-bed artificial drying utilizes forced heated air passed upward through a bulk layer of grains. This process creates a distinct drying zone that moves gradually from the bottom of the bin to the top. The grains at the bottom dry first as they contact the dry air, while the upper layers dry later.

184. (C) Standard milling yields roughly 65-70% total milled rice, with the remainder being outer husk and bran.
The industrial milling of raw paddy yields a standard recovery of approximately sixty-five to seventy percent total milled rice. This recovered portion includes both whole head rice and broken grains. The remaining thirty to thirty-five percent consists of the inedible outer husk, which is removed during dehusking, and the nutrient-rich bran layer.

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chemically retained by the plant for cellular metabolic processes.

148. (C) Soil evaporation dominates early on, but transpiration dominates once the canopy covers the soil.
Evapotranspiration components shift significantly as a crop develops. Early in the season, when the ground is bare, water loss is dominated by soil evaporation. However, as the plant canopy expands and shades the soil, direct evaporation decreases. Consequently, active transpiration from the leaf surfaces becomes the primary component of total water loss.

149. (C) P-3, Q-4, R-2, S-1
Different crops possess highly specific growth stages sensitive to moisture deficits. For maize, the tasseling and silking phase is extremely critical. Groundnuts require ample moisture during pegging and pod formation. Sugarcane depends on water during its early vegetative formative phase, while potato yields are highly sensitive to stress during tuber initiation and development.

150. (D) C_4 crops intrinsically exhibit a lower water-use efficiency than C_3 crops under identical climatic conditions
C_4 crops like maize and sorghum exhibit higher water-use efficiency than C_3 crops under identical climatic conditions. This superior efficiency is due to their specialized Kranz anatomy and PEP carboxylase pathway, which allow C_4 plants to fix carbon dioxide efficiently even with partially closed stomata, thereby conserving water under hot and dry conditions.

151. (B) It causes pollen sterility and grain abortion, severely reducing the final crop yield.
Moisture stress during flowering or anthesis is highly destructive to cereal crop production. Drought at this critical phase disrupts microsporogenesis, causing widespread pollen sterility and grain abortion. Because the reproductive organs are physically damaged, fertilization fails, leading to poor grain set and a severe, permanent decline in the final harvested crop yield.

152. (C) Late physiological maturity and senescence in wheat
Irrigation scheduling must target developmental stages where moisture stress causes severe damage. While flowering, pod development, and booting stages are highly critical across legumes, oilseeds, and cereals, the late physiological maturity phase is not sensitive to stress. At this final stage, the grains are already fully filled, and plant tissues are naturally drying.

153. (D) When soil moisture is abundant and non-limiting for a fully established canopy.
Actual evapotranspiration is the real amount of water lost from a cropped field. Potential evapotranspiration represents the maximum possible water loss under prevailing atmospheric conditions. Actual evapotranspiration equals potential evapotranspiration only when soil moisture is highly abundant and non-limiting, allowing a fully established crop canopy to transpile freely without experiencing stomatal resistance.

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154. (B) 15 to 45 days after sowing
The critical period of crop-weed competition represents the growth interval during which weed presence causes the greatest yield loss. For direct-seeded rice, this period occurs fifteen to forty-five days after sowing. During this early developmental window, slow crop growth allows aggressive weeds to quickly outcompete rice seedlings for light, nutrients, and soil water.

155. (B) A chemical that controls specific weed species without causing injury to the crop at recommended rates.
Selective herbicides are specialized chemical compounds engineered to control specific weed species while leaving the co-cultivated crop completely unharmed. This selectivity depends on anatomical differences, physical positioning, crop metabolism, or specialized enzymatic pathways that rapidly detoxify the herbicide within the crop tissues while allowing toxic concentrations to accumulate in targeted weed species.

156. (B) The inherited ability of a weed biotype to survive a herbicide dose that would normally be lethal to the wild population.
Herbicide resistance in weed populations represents an evolutionary process driven by repeated chemical applications. It is defined as the inherited physiological ability of a specific weed biotype to survive and reproduce after exposure to a herbicide dose that is normally

lethal to the wild population, resulting from genetic mutations or altered enzyme targets.

157. (A) It is a competitive grassy annual weed that physically mimics wheat in its early vegetative growth stages.
Phalaris minor is an extremely problematic annual grass weed in wheat crops. It exhibits strong morphological mimicry, appearing visually identical to young wheat plants during early vegetative growth stages. This physical similarity makes manual weeding difficult, allowing the weed to compete aggressively with the wheat crop for critical nutrients, sunlight, and moisture.

158. (B) II and IV
Pre-emergence herbicides must be applied to the soil immediately after sowing but before crop and weed seedlings emerge. Applying them after canopy development is incorrect. Additionally, parasitic weeds like Striga target graminaceous cereal crops such as sorghum, maize, and sugarcane rather than broadleaf legumes, making statements II and IV incorrect.

159. (D) The chemical must be applied directly to the weed foliage for effective absorption
Pre-emergence herbicides are formulated to target emerging weed seedlings as they germinate in the soil. The active chemical must be applied directly to the soil surface, forming a toxic barrier, rather than applied to weed foliage. The emerging shoots or roots absorb the chemical from this soil layer, which halts early cellular division.

160. (C) The weed attaches to the tobacco roots as an obligate parasite, draining water and nutrients to stunt the host.
Orobanche is a genus of aggressive root parasites that lack chlorophyll. The weed seedling attaches to the roots of the host tobacco plant through specialized feeding organs called haustoria. By establishing this direct vascular connection, the parasite drains water, minerals, and organic nutrients, causing severe stunting and yield loss in tobacco.

161. (B) Glyphosate
While 2,4-D, metsulfuron-methyl, and pendimethalin exhibit selective action under standard agronomic applications, glyphosate is a non-selective systemic herbicide. It targets and inhibits the EPSP synthase enzyme, which is common to almost all green plants. Consequently, glyphosate destroys all treated vegetation and crops on contact, requiring targeted spot applications or transgenic resistance.

162. (D) Grassy growing points are protected and resist 2,4-D, whereas broadleaf weeds undergo lethal growth.
The herbicide 2,4-D is selective for broadleaf weeds in cereal crops like wheat. This selectivity occurs because monocots protect their growing points within whorls, possess closed vascular bundles, and metabolize the chemical rapidly. Conversely, broadleaf weeds absorb 2,4-D efficiently, which triggers uncontrolled, distorted growth and vascular collapse, leading to rapid plant death.

163. (A) It was linked to myocardial lipidosis and poor human cardiovascular health.
Reducing erucic acid content in improved mustard varieties is an important quality goal. High levels of erucic acid are linked to myocardial lipidosis and other cardiovascular issues in humans. Breeding low-erucic acid mustard varieties, often called canola-equivalent or single-zero cultivars, makes the oil safe and highly suitable for regular human consumption.

164. (C) The combined measure of fiber fineness and maturity determined through air permeability.
In cotton quality assessment, the micronaire value is a key commercial metric. It provides a combined measurement of fiber fineness and cell wall maturity. The laboratory test works by measuring air flow resistance through a compressed plug of cotton fibers, helping textile mills accurately assess yarn spinning performance and dye absorption uniformity.

165. (A) Globulins
In pulse crops (grain legumes), the primary storage proteins are classified as globulins, which comprise seventy percent of the total protein content. These globulins, mainly vicilin and legumin, are soluble in dilute salt solutions. While cereals are rich in prolamins and glutelins, pulses accumulate globulins, which are rich in lysine but low in sulfur amino acids.

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166. (D) Gluten is formed by hydrating gliadin and glutenin, providing crucial elasticity and extensibility.
Gluten is a composite protein network formed when wheat flour is hydrated and kneaded. It is composed of two primary protein fractions: gliadin, which provides dough with cohesive properties and extensibility, and glutenin, which imparts elasticity and strength. This unique combination traps carbon dioxide during fermentation, giving bread its characteristic rise and structure.

167. (B) Staple length, Micronaire, Bundle strength
Evaluating cotton fiber quality involves measuring physical dimensions, fineness, and mechanical strength. This progression moves logically from staple length, which is a physical linear measurement, to micronaire value, which reflects fiber fineness and cell wall development, and finally to bundle strength, which measures the tensile force required to break a fiber bundle.

168. (C) Traditional rapeseed-mustard oil contains very low levels of erucic acid natively
Sunflower and safflower oils are valued for their high concentrations of polyunsaturated linoleic acid, while groundnut oil has high oleic and linoleic acid levels. However, traditional rapeseed-mustard oil naturally contains high levels of erucic acid, often exceeding forty percent. Breeding efforts have sought to reduce these levels to create healthier varieties.

169. (D) It acts as a toxic polyphenolic compound, limiting the use of seed cake as feed for monogastric animals.
Gossypol is a naturally occurring polyphenolic compound found in pigment glands throughout the cotton plant, especially in the seeds. It acts as a defense mechanism against herbivores but is toxic to monogastric animals like swine and poultry. Consequently, high gossypol content limits the use of cotton seed meal in livestock rations.

170. (A) Glutamine
In nutritional quality evaluations of cereal and pulse proteins, essential amino acids like lysine, tryptophan, and methionine are critical metrics. These amino acids must be obtained through the diet because monogastric organisms cannot synthesize them. Glutamine, however, is a non-essential amino acid that the body can readily synthesize from other metabolic precursors.

171. (B) Maize predominantly contains zein, whereas wheat contains gluten (gliadin and glutenin proteins).
Maize and wheat differ significantly in their dominant seed storage protein fractions. Maize kernels predominantly accumulate zein, which is a prolamin protein that lacks sufficient lysine and tryptophan. In contrast, wheat grains accumulate gluten, which is composed of gliadin and glutenin proteins. This unique gluten protein network provides the cohesive, elastic properties required for baking.

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172. (B) Maize
In maize cultivation, the visual formation of a distinct black layer at the base of the kernel is a key indicator of physiological maturity. This black layer forms when the vascular cells connecting the kernel to the cob transfer their final sugars, collapse, and die. It signals that maximum seed dry weight accumulation has finished.

173. (A) The stage when seed dry matter accumulation stops and the vascular connection to the parent plant is severed.
Physiological maturity is agronomically defined as the developmental stage when the crop reaches its maximum dry matter accumulation. At this point, the vascular pathway connecting the seed to the maternal plant is severed, halting further nutrient transfer. It represents the peak of seed development, although the seed must dry further before harvesting.

174. (C) It estimates total soluble solids in the juice, with a reading of 18-20 typically indicating maturity.
A Brix refractometer is used in sugarcane farming to estimate the concentration of total soluble solids, primarily sucrose, within the juice. Refractometer readings of eighteen to twenty percent usually indicate that the cane has reached optimal maturity. This measurement helps farmers determine the correct harvesting window to maximize industrial sugar recovery.

175. (D) Crops mature at 30-35% moisture but are harvested at 18-22% to avoid mechanical damage to grains.
Cereal grains reach physiological maturity when seed moisture is around thirty to thirty-

manufacture particle boards and fuel. Cottonseed hulls are valuable ruminant feed rather than toxic waste, making statements I, III, and IV correct.

195. (A) Wet milling is specifically designed to produce whole-grain cornmeal for direct baking
Industrial wet milling of maize is designed to separate the kernel into its distinct components, namely starch, germ, gluten, and fiber, rather than to produce whole-grain cornmeal. The process begins with sulfur dioxide steeping to soften the kernel. The separated germ is used for oil extraction, while the starch is processed into sweeteners or bioplastics.

196. (C) Accumulating ethanol eventually becomes toxic to yeast cells, halting fermentation at tolerance limits.
During industrial bioethanol production, yeast cells ferment simple sugars to produce ethanol and carbon dioxide. However, as the ethanol concentration in the fermentation mash rises, it eventually becomes toxic to the yeast cells. This accumulation disrupts their cell membranes and halts metabolic activity when the organism's maximum tolerance limit is reached.

197. (A) Direct formulation of highly concentrated nitrogen fertilizers
Extracted plant starches are widely used across multiple industries. They serve as sizing agents in the textile and paper industries, raw materials for high-fructose corn syrup, and base materials for biodegradable bioplastics. However, plant starches are not used to formulate nitrogen fertilizers, which are synthesized chemically from atmospheric nitrogen via the Haber-Bosch process.

198. (D) First-generation uses food crops, whereas second-generation relies on non-food lignocellulosic biomass.
First-generation and second-generation biofuels are distinguished by their raw feedstocks. First-generation biofuels are produced from food crops like corn, wheat, and sugarcane. In contrast, second-generation biofuels are derived from non-food lignocellulosic biomass, including crop residues like wheat straw, wood waste, and dedicated fast-growing energy crops, reducing direct competition with food security.

199. (B) Cost A_1 plus rent paid for leased-in land
In Indian agricultural economics, Cost A_2 is a specific operational cost concept. It is calculated by adding the actual rent paid for leased-in land to Cost A_1, which comprises all out-of-pocket cash and in-kind expenses incurred by the farmer. This metric helps economists evaluate the real operating costs for tenant farmers.

200. (C) The ratio of the present value of gross returns to the present value of total project costs.
The benefit-cost ratio is a fundamental tool for evaluating project economics. It is mathematically defined as the ratio of the present value of gross financial returns or benefits to the present value of total operational costs. A ratio greater than one indicates that the project is economically viable and generates net positive returns.

201. (D) It is a comprehensive cost covering actual expenses, rental values, interest, and family labor.
In Indian agricultural economics, Cost C (or C_2) is the most comprehensive cost concept. It accounts for all actual cash and in-kind operational expenses, the rental value of owned land, interest on fixed capital assets, and the imputed value of unpaid family labor. This metric provides a complete assessment of the true economic cost of cultivation.

202. (A) Gross return is total income from all sales, whereas net return is gross return minus total cultivation cost.
Gross returns and net returns represent distinct financial measurements in farm business accounting. Gross return is the total revenue generated from selling the primary crop yield and any secondary byproducts. Net return, in contrast, represents the actual profit remaining after subtracting the total cost of crop cultivation from the gross return.

203. (B) 2, 3, 1
Standard cost concepts in agricultural economics range from narrow, direct expenses to highly comprehensive, inclusive calculations. Cost A_1 is the narrowest concept, covering only direct, out-of-pocket operating expenses. Cost B is broader, adding interest on fixed capital and land rental values. Cost C is the most comprehensive, additionally incorporating the imputed value of family labor.

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185. (B) II and IV
The fermentation of tea leaves is an enzymatic oxidation process driven by endogenous polyphenol oxidase rather than anaerobic bacteria. Additionally, the flue-curing of Virginia tobacco relies on heat transferred through metal pipes or flues rather than direct exposure to smoke. This distinction makes both statement II and statement IV incorrect.

186. (A) The critical "fermentation" step is a microbial process requiring the inoculation of external yeast cultures.
In black tea processing, the traditional term "fermentation" is technically a misnomer because it does not involve microbes or yeast inoculation. Instead, it is a natural chemical process of enzymatic oxidation. During this step, polyphenol oxidase enzymes inside the crushed leaves react with oxygen, converting green catechins into red-brown theaflavins and thearubigins.

187. (B) High moisture favors Aspergillus flavus growth, leading to dangerous kernel contamination with aflatoxins.
Storing groundnuts under poor ventilation with moisture levels above nine percent creates an environment highly favorable for fungal pathogens. Specifically, it triggers the rapid growth of Aspergillus flavus, which contaminates the kernels with carcinogenic metabolites known as aflatoxins. This contamination poses serious health risks and renders the crop unusable for food or oil extraction.

188. (B) Citrus
Climacteric fruits undergo a sudden surge in respiration and ethylene production during ripening, allowing them to be harvested green and ripened post-harvest, as seen in bananas, tomatoes, and mangoes. Citrus fruits, however, are non-climacteric. They do not experience this respiratory spike and must ripen fully on the tree before they are harvested.

189. (A) It depends on weather conditions and exposes grain to contamination by environmental dust, birds, and pests.
While traditional sun drying is low-cost, it has several operational limitations. This open-air method depends heavily on weather conditions, making it ineffective during cloudy or rainy periods. Additionally, leaving grains spread out in the open exposes them to direct contamination from birds, rodents, insects, windblown dust, and various environmental pollutants.

190. (C) 70 to 75%
A standard mature maize kernel contains approximately seventy to seventy-five percent starch by dry weight. This rich starch is stored in the endosperm, which makes up the bulk of the kernel's internal structure. The remaining portion of the kernel consists of proteins, crude fiber, lipids concentrated in the germ, and mineral ash.

191. (D) Ethyl alcohol produced via yeast fermentation of sugars from crops like sugarcane or grain corn.
Bioethanol is chemically defined as ethyl alcohol produced by fermenting simple sugars derived from agricultural crops. It is generated through the biochemical action of yeast species, primarily Saccharomyces cerevisiae, on sugar-rich crops like sugarcane or starch-rich grains like corn, which must be enzymatically hydrolyzed into fermentable sugars prior to yeast fermentation.

192. (C) It a dark, viscous byproduct containing uncrystallized sugars used for distillery fermentation.
Molasses is a dark, heavy, viscous liquid byproduct obtained during the industrial crystallization of sugar from cane juice. It contains a high concentration of uncrystallized, fermentable sugars. This composition makes molasses a highly valuable raw material for distilleries, where it is fermented with yeast to produce industrial alcohol, bioethanol, and rum.

193. (B) It is used as a boiler biofuel for electricity cogeneration and as a raw material for paper pulp.
Bagasse is the fibrous, woody residue that remains after juice is extracted from sugarcane stalks. It has important industrial uses, serving as a primary biofuel burned in sugar mill boilers to generate steam and electricity. Additionally, bagasse is utilized as a raw material for producing paper pulp, cardboard, and eco-friendly packaging.

194. (B) I, III and IV
Rice bran is a rich source of edible oil extracted via solvents. Press mud from sugar mills serves as a soil amendment that adds organic matter and plant nutrients. Jute sticks are used to

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biochemical secondary metabolites, known as allelochemics, into the surrounding environment. These substances are released via root exudates, leaf leaching, or decomposition, and they directly inhibit the germination, growth, or survival of adjacent crop species.

121. (D) Food crops are grown in wide alleys formed by rows of fast-growing, nitrogen-fixing leguminous shrubs or trees.
Alley cropping, also called hedgerow intercropping, is an agroforestry system where arable food crops are cultivated in the wide spaces between rows of woody shrubs or trees. Typically, fast-growing, nitrogen-fixing leguminous tree species are selected. These trees are regularly pruned to prevent shading of crops, while the prunings provide nutrient-rich green mulch.

122. (A) P-4, Q-1, R-2, S-3
Agroforestry classifications are defined by their structural components. Silvi-pasture integrates forest trees and forage plants for livestock. Agri-silvi-pasture combines woody perennials, agricultural crops, and pasture or animals. Horti-silviculture involves growing fruit-producing trees alongside timber or fuelwood trees. Aqua-forestry integrates trees with fish production, where foliage provides nutrients or shade to aquaculture ponds.

123. (B) Continuous, intense overgrazing enhances the establishment and survival of young tree seedlings in pasture.
Managing a silvi-pasture system requires balancing tree growth and pasture utilization. Understory forage species must tolerate partial shade, and trees should yield nutritious fodder during dry periods. Continuous, intense overgrazing is highly detrimental because animals physically trample, damage, and consume young tree seedlings, which severely prevents their establishment, survival, and long-term regeneration.

124. (B) It severs lateral feeder roots, reducing below-ground competition for water and nutrients with adjacent crops.
In agroforestry systems, trees and crops compete for underground water and essential nutrients. Conducting systematic tree root pruning severs the shallow lateral feeder roots of the trees that spread into the crop root zone. This physical barrier creation reduces underground resource competition, allowing adjacent seasonal crops to access sufficient soil moisture and nutrients.

125. (A) Intensive crop monoculture
Structural classifications of agroforestry systems describe how woody perennials are combined with crops or animals. Agri-silviculture, silvi-pasture, and agri-horticulture are all recognized agroforestry systems that integrate multiple species on the same land. Intensive crop monoculture, however, is a simplified modern farming system that excludes trees to grow a single agricultural crop species.

126. (C) Shifting cultivation is a sequential temporal system, whereas alley cropping is a simultaneous spatial system.
Agroforestry designs are arranged based on space and time. Shifting cultivation represents a sequential temporal system, where crop production and forest fallow cycle alternate over successive years on the same land. In contrast, alley cropping utilizes a simultaneous spatial design, where food crops and woody hedgerow species grow together side-by-side during the same season.

127. (D) CORH-1
CORH-1 holds the historical distinction of being the first commercially released rice hybrid in India, developed and officially released in 1994 by Tamil Nadu Agricultural University in Coimbatore. While IR8 and Jaya were landmark high-yielding dwarf varieties of the Green Revolution, they were inbred selections rather than commercial F_1 hybrids.

128. (C) The agronomic or genetic enhancement of food crops to increase the level and bioavailability of essential nutrients.
Bio-fortification is academically defined as the process of increasing the nutritional value of food crops during their growth. This is achieved through agronomic practices, selective plant breeding, or modern genetic engineering. By targeting essential micronutrients and vitamins directly within the plant endosperm, bio-fortification increases nutrient bioavailability compared to artificial post-harvest food fortification.

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204. (B) The imputed wage of family labor is generally excluded from the calculation of Cost C
Imputed costs estimate the economic value of resources owned and provided by the farmer without direct cash payments, such as owned land and family labor. Excluding these costs can lead to an overestimation of true profitability. In cost analysis, the imputed wage of family labor is specifically included in Cost C, making the assertion of its exclusion incorrect.

205. (A) Subsidies reduce out-of-pocket input costs without lowering gross returns, increasing the farmer's B:C ratio.
Subsidies reduce out-of-pocket input costs without affecting gross returns, thereby increasing the farmer's Benefit:Cost (B:C) ratio. Since the denominator (cost) decreases while the numerator (returns) remains unchanged, profitability improves. Fertilizer subsidies encourage input use and reduce production expenses. The other options are incorrect because subsidies neither increase cultivation costs, proportionally reduce returns, nor directly lower crop market prices.

206. (C) Depreciation charges on machinery and farm buildings
Depreciation charges on machinery and farm buildings are correct because they are fixed costs that occur regardless of the level of crop production. Variable costs change with the extent of cultivation and include expenses such as seeds, hired labor, fertilizers, pesticides, and herbicides. Therefore, depreciation is excluded from the variable cost category, while the remaining options represent typical operational expenses.

207. (D) The rental value of owned land plus rent paid for leased land
The rental value of owned land along with rent paid for leased land is correct because Cost B_2 is obtained by adding land charges to Cost B_1. Cost B_1 already includes Cost A_1/A_2 plus interest on owned fixed capital, excluding land. The other options are accounted for under different cost concepts and are not the distinguishing component between Cost B_1 and Cost B_2.

208. (C) Sugarcane
Sugarcane is correct because it has one of the highest consumptive water requirements among field crops due to its long growth duration, high biomass production, and continuous transpiration. Its seasonal water requirement generally exceeds that of wheat, groundnut, and sorghum. Efficient irrigation scheduling is therefore essential to achieve high cane yield while minimizing unnecessary water losses.

209. (B) Growth is dictated not by total resources, but by the scarcest resource acting as a limiting factor.
Growth is dictated by the scarcest resource because Liebig's Law of the Minimum states that crop productivity is limited by the nutrient or environmental factor in shortest supply relative to plant needs. Increasing non-limiting resources cannot compensate for the deficient factor. The remaining options incorrectly assume unlimited responses to nutrient application or attribute crop growth to only one environmental factor.

210. (D) Cotton – Prominent deep taproot system
Cotton is correct because it develops a strong and deep taproot that enables efficient extraction of water and nutrients from deeper soil layers, improving drought tolerance. Pearl millet has a fibrous root system, chickpea possesses a well-developed taproot rather than a shallow fibrous system, and maize also develops a fibrous root system supported by adventitious and brace roots rather than tuberous roots.

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Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2017
81. In intercropping, the Aggressivity index measures:
(A) Competitive relationship and dominance of crops.
(B) The total biomass production of the entire system.
(C) The overall efficiency of biological nitrogen fixation.
(D) The water use efficiency of the intercropping system.

2016
82. Pooled analysis of variance is conducted to analyze data from:
(A) A single replication within one field trial.
(B) Solely un-replicated observational data points.
(C) Multi-environment trials.
(D) A simple controlled laboratory environment experiment.

2025
83. Before performing a pooled ANOVA across locations, one must test for:
(A) Homogeneity of error variances.
(B) Homogeneity of treatment means.
(C) Equality of degrees of freedom.
(D) Perfect linear correlation.

2011
84. Which statistical test is commonly employed to evaluate the homogeneity of variances prior to a pooled ANOVA?
(A) Student's t-test
(B) Mann-Whitney test
(C) Wilcoxon signed-rank test
(D) Bartlett's test

2017
85. In a multi-location trial ANOVA, a significant Genotype $\times$ Environment ($G \times E$) interaction indicates that:
(A) All genotypes perform completely equally across all environments.
(B) Genotypes respond differently to environments.
(C) The chosen trial environments are completely homogeneous.
(D) Blocking was proven to be entirely ineffective in all locations.

2005
86. Which measure of central tendency cannot be determined graphically using an ogive?
(A) Median
(B) Quartiles
(C) Mean
(D) Deciles

2001
87. A distribution where the mean, median, and mode are identical is:
(A) Positively skewed
(B) Negatively skewed
(C) Bimodal
(D) Symmetrical

2015
88. In a positively skewed distribution, the relationship among measures of central tendency is generally:
(A) Mean $>$ Median $>$ Mode
(B) Mean $<$ Median $<$ Mode
(C) Mean $=$ Median $=$ Mode
(D) Mode $>$ Mean $>$ Median

2023
89. The second quartile of a data set corresponds exactly to the:
(A) Arithmetic mean
(B) Median
(C) Mode
(D) Variance

2016
90. Arrange the calculation steps for variance of grouped data in the correct order:
I. Calculate deviations of midpoints from the mean.
II. Multiply squared deviations by class frequencies.
III. Find the midpoints of the class intervals.
IV. Sum the products and divide by total frequency minus one.
(A) III, I, II, IV
(B) I, III, II, IV
(C) III, II, I, IV
(D) I, II, III, IV

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2007
91. The empirical relationship between mean, median, and mode in a moderately asymmetrical distribution is:
(A) Mode $=$ 3 Median $-$ 2 Mean
(B) Mode $=$ 2 Median $-$ 3 Mean

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List II: (Properties)

1. Appropriate for average rates and speeds
2. Minimizes sum of squared deviations
3. Most frequent value in a dataset
4. Best for averaging ratios and percentages

(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-3, R-2, S-1

2002

10. Consider the following statements about measures of dispersion:

I. Range is based on all observations.
II. Variance is the square of standard deviation.
III. Standard deviation is independent of change of origin.
IV. Standard deviation is independent of change of scale.

Which of the above statements are incorrect?
(A) I and III
(B) I and IV
(C) II and III
(D) II and IV

2025

11. Which measure of dispersion is expressed in the same units as the original data?
(A) Standard deviation
(B) Variance
(C) Coefficient of variation
(D) Regression coefficient

2009

12. If a constant c is added to every observation in a dataset, the new variance will:
(A) Increase by c
(B) Increase by c^2
(C) Remain unchanged
(D) Multiply by c

2023

13. What is the fundamental difference between standard deviation (SD) and standard error of mean (SE)?
(A) SD evaluates total population size while SE evaluates sample size limitations.
(B) SE consistently exceeds SD values for any sample sizes greater than unity.
(C) SD applies specifically to continuous parameters while SE applies to discrete metrics.
(D) SD measures sample variation while SE measures mean precision.

2006

14. For a sample of size n and standard deviation s, the standard error of the mean is calculated as:
(A) $\frac{s}{n}$
(B) $\frac{s^2}{n}$
(C) $\frac{s}{\sqrt{n}}$
(D) $\frac{\sqrt{s}}{n}$

2008

15. Select the correct sequence of steps to calculate the coefficient of variation (CV):
(A) Calculate standard deviation → Calculate mean → Divide mean by SD and multiply by 100
(B) Calculate mean → Calculate variance → Calculate standard deviation → Divide SD by mean and multiply by 100
(C) Calculate mean → Calculate standard error → Divide SE by mean and multiply by 100
(D) Calculate variance → Calculate mean → Divide variance by mean and multiply by 100

2005

16. In field experiments, the Coefficient of Variation (CV) is primarily used to evaluate:
(A) The magnitude of treatment effects.
(B) The selection of optimum plot sizes.
(C) The total number of required replications.
(D) Experimental precision.

2011

17. Which of the following CV values typically indicates acceptable reliability in agricultural field experiments?
(A) Less than 5%
(B) 10% to 15%
(C) 30% to 40%
(D) Above 50%

2008

18. A scatter diagram showing points spreading widely across all four quadrants typically indicates:
(A) Perfect positive correlation
(B) Perfect negative correlation
(C) Zero or near-zero correlation
(D) High non-linear correlation

2019

19. Pearson's product-moment correlation coefficient is bounded between:

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(A) -1 and +1
(B) -1 and 0
(C) 0 and 1
(D) -infinity and +infinity

2012

20. Consider the following statements regarding correlation:
I. Correlation implies causation.
II. Spearman's rank correlation is a non-parametric measure.
III. Pearson's coefficient is sensitive to extreme values.
IV. A correlation coefficient of -0.85 indicates a weak relationship.
V. Correlation measures linear association between two variables.
Which of the above statements are correct?
(A) II, III and V
(B) I, II and IV
(C) III, IV and V
(D) I, III and V

2024

21. Which assumption is required for Pearson's correlation but not for Spearman's rank correlation?
(A) Both variables in the analysis must be strictly discrete values.
(B) Data follow a bivariate normal distribution.
(C) The underlying relationship must be strictly monotonic in nature.
(D) The total size of the sample must exceed one hundred units.

2025

22. In simple linear regression, the line of best fit is derived by minimizing the sum of:
(A) Absolute residuals
(B) Orthogonal distances
(C) Squared residuals
(D) X-variable variations

2006

23. If the regression coefficient of Y on X is positive, the regression coefficient of X on Y must be:
(A) Negative
(B) Zero
(C) Undefined
(D) Positive

2002

24. The geometric mean of two regression coefficients yields the:
(A) Correlation coefficient
(B) Coefficient of determination
(C) Standard error of estimate
(D) Variance ratio

2009

25. Arrange the following steps to test the significance of a correlation coefficient in correct order:
I. Calculate the t-statistic
II. Determine degrees of freedom $(n-2)$
III. Set the null hypothesis $(\rho = 0)$
IV. Compare with critical t-value
(A) III, I, II, IV
(B) III, II, I, IV
(C) I, II, III, IV
(D) II, I, IV, III

2006

26. The coefficient of determination (R^2) represents:
(A) The ratio of unexplained variance to total variance.
(B) The proportion of total variation in Y explained by X.
(C) The square root of the correlation coefficient.
(D) The difference between regression and residual mean squares.

2017

27. If $r = 0.8$, the coefficient of determination is:
(A) 0.80
(B) 0.64
(C) 0.40
(D) 0.16

2009

28. Which test is used to assess the significance of the regression coefficient in a simple linear regression model?
(A) Chi-square test
(B) Z-test
(C) F-test or t-test
(D) Mann-Whitney U test

NODIA

2002

29. A Type I error occurs when a researcher:
(A) Accepts a false null hypothesis.
(B) Rejects a false null hypothesis.
(C) Accepts a true null hypothesis.
(D) Rejects a true null hypothesis.

2018

30. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The level of significance represents the maximum allowable probability of committing a Type I error.
Reason (R): Decreasing the level of significance

simultaneously reduces the probability of a Type II error.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019
31. The power of a statistical test is mathematically defined as:
(A) The overall probability of committing a Type I error.
(B) One minus probability of Type II error.
(C) One minus the overall probability of a Type I error.
(D) The overall probability of committing a Type II error.

2014
32. Degrees of freedom in a simple one-sample t-test with sample size n are:
(A) n
(B) $n-1$
(C) $n-2$
(D) $n+1$

2015
33. Under which condition is a paired t-test preferred over an independent two-sample t-test?
(A) When observations in both groups are paired or correlated.
(B) When the sample sizes from the two groups are highly unequal.
(C) When comparing treatment means from completely independent groups.
(D) When both population variances are already known and constant.

2013
34. For testing the difference between means of two independent samples with unknown but equal variances, the appropriate test statistic relies on:
(A) Standard error derived from a single sample
(B) Chi-square distribution
(C) Pooled sample variance
(D) Regression mean square

2018
35. Match the test statistics (List I) with their applications (List II):
List I: (Test Statistic)
P. Paired t-test
Q. F-test
R. Chi-square test
S. Z-test
List II: (Application)
1. Equality of two population variances
2. Goodness of fit for count data
3. Difference between means of large samples ($n > 30$)
4. Difference between means of pre/post treatments
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-2, R-1, S-3

2010
36. An F-test evaluates the equality of two variances by calculating:
(A) The absolute difference between the variances
(B) The product of the two sample variances
(C) The sum of the two sample variances
(D) The ratio of the two sample variances

2013
37. In Analysis of Variance (ANOVA), the total sum of squares is partitioned into:
(A) Regression and correlation sums of squares.
(B) Treatment and error sums of squares.
(C) Mean sum of squares and median sum of squares.
(D) Block sum of squares and pooled sample variance.

2025
38. The F-ratio in a one-way ANOVA is defined as:
(A) Error Mean Square / Treatment Mean Square
(B) Total Mean Square / Error Mean Square
(C) Treatment Mean Square / Error Mean Square
(D) Treatment Sum of Squares / Total Sum of Squares

2006
39. The degrees of freedom for the error term in a completely randomized design with t treatments and r replications per treatment is:
(A) $t-1$
(B) $r-1$
(C) $t(r-1)$
(D) $rt-1$

2012
40. Consider the following statements regarding the Chi-square goodness of fit test:

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CHAPTER 07
Agricultural Statistics

2001

1. Which of the following defines a discrete variable in agricultural data?
(A) It takes only isolated, countable values.
(B) It can take any real value within a given range.
(C) It describes qualitative attributes without magnitude.
(D) It categorizes data based on ranks only.

2005

2. What distinguishes a quantitative variable from a qualitative variable?
(A) Qualitative variables follow continuous probability distributions.
(B) Quantitative variables are applied exclusively to nominal scale data.
(C) Quantitative variables represent measurable numerical properties.
(D) Qualitative variables are strictly measured using standard metric units.

2025

3. Consider the following statements about agricultural variables:
I. Plant height is a continuous variable.
II. Number of tillers per plant is a discrete variable.
III. Grain color is a quantitative variable.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2017

4. In a frequency distribution, how is a class mark calculated?
(A) By calculating the sum of the upper limits of all defined classes.
(B) By finding the difference between consecutive class lower limits.
(C) By dividing the total cumulative frequency by the number of classes.
(D) By averaging the lower and upper limits of a class.

2010

5. Which term describes a cumulative frequency calculated by summing frequencies from the highest class down to the lowest?
(A) Less than cumulative frequency
(B) More than cumulative frequency
(C) Relative frequency
(D) Percentage frequency

2004

6. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The median is preferred over the mean in highly skewed distributions.
Reason (R): The mean is heavily influenced by extreme values, whereas the median is positional.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2006

7. Which measure of central tendency minimizes the sum of absolute deviations?
(A) Arithmetic mean
(B) Harmonic mean
(C) Mode
(D) Median

2019

8. The sum of deviations of individual observations from their arithmetic mean is always equal to:
(A) Zero
(B) One
(C) The variance
(D) The standard deviation

2011

9. Match the measures of central tendency (List I) with their properties (List II):
List I: (Measures of Central Tendency)
P. Arithmetic Mean
Q. Geometric Mean
R. Harmonic Mean
S. Mode

(B) III and IV
(C) II and III
(D) II and IV

2004

51. The primary purpose of blocking in an RBD is to:
(A) Maximize between-block and minimize within-block variance.
(B) Maximize differences within blocks to elevate experimental error.
(C) Minimize differences between blocks to simplify treatment layout.
(D) Randomize the treatments completely across all available plots.

2010

52. For an RBD with t treatments and r replications, the error degrees of freedom are:
(A) $(t-1)+(r-1)$
(B) $(t-1)(r-1)$
(C) $tr-1$
(D) $t(r-1)$

2009

53. If a fertility gradient runs from North to South in a field, how should the blocks be oriented in an RBD?
(A) North to South
(B) East to West
(C) Diagonally
(D) Circularly

2003

54. When a plot value is missing in an RBD, what is the immediate consequence for the ANOVA?
(A) The total degrees of freedom increases by 1.
(B) The treatment degrees of freedom decreases by 1.
(C) The orthogonality of the design is lost.
(D) The F-ratio must be recalculated using non-parametric tests.

2009

55. The formula for estimating a single missing value in an RBD with t treatments and r blocks is:
(A) $\frac{rB+tT-G}{(r-1)(t-1)}$
(B) $\frac{rB+tT+G}{(r-1)(t-1)}$
(C) $\frac{rB-tT+G}{(r-1)(t-1)}$
(D) $\frac{rB+tT-G}{r \cdot t}$

NODIA

2009

56. After substituting an estimated missing value in an RBD, the error degrees of freedom must be:
(A) Increased by 1
(B) Reduced by 1
(C) Reduced by 2
(D) Left unchanged

2013

57. Which data transformation is most appropriate for count data exhibiting a Poisson distribution where variance equals the mean?
(A) Logarithmic transformation
(B) Square root transformation
(C) Arcsine transformation
(D) Reciprocal transformation

2002

58. Logarithmic transformation is typically applied when:
(A) Data are expressed as percentages bounded by 0 and 100.
(B) The standard deviation is proportional to the mean.
(C) The variance is equal to the mean.
(D) The data follow a perfectly normal distribution.

2007

59. Arcsine (angular) transformation is recommended for percentage data specifically when:
(A) Values range widely, extending outside 30% to 70%.
(B) Values lie uniformly within the 30% to 70% interval.
(C) The observations represent very large positive integers.
(D) The coefficient of variation is exceptionally low here.

2003

60. Consider the following statements about data transformations:
I. Square root transformation is used for rare event counts.
II. Log transformation requires adding a constant if zeros are present.
III. Arcsine transformation is used for normally distributed continuous data.
IV. Transformations alter the underlying hypothesis being tested.
V. Transformations aim to stabilize variance.
Which of the above statements are correct?
(A) I, II and V
(B) II, III and IV

(C) I, III and V
(D) I, IV and V

2017

61. Factorial experiments are advantageous primarily because they:
(A) Substantially reduce the total number of plots needed.
(B) Completely eliminate the necessity for plot replication.
(C) Test all primary factors exclusively at a single level.
(D) Evaluate interaction effects between multiple factors.

2022

62. In a 2^3 factorial experiment, how many total treatment combinations are present?
(A) 6
(B) 8
(C) 9
(D) 16

2002

63. The degrees of freedom for the interaction effect $A \times B$ in a factorial experiment with factor A at a levels and factor B at b levels is:
(A) $a + b - 2$
(B) $(a-1)(b-1)$
(C) $ab - 1$
(D) $ab(r-1)$

2025

64. Main effects in a factorial design represent:
(A) The combined synergistic effect of two factors minus the experimental error.
(B) The biological effect of a factor at the highest level of another factor.
(C) The difference between the highest and lowest treatment combinations only.
(D) The simple effect of a factor averaged over all other factor levels.

2025

65. Confounding in factorial experiments is a technique used to:
(A) Reduce block size by sacrificing high-order interactions.
(B) Increase the overall dimensions of complete block designs.
(C) Completely eliminate any potential experimental error variance.
(D) Accurately estimate missing plot observations in the field.

2014

66. In complete confounding of a 2^3 experiment replicated r times, the confounded interaction cannot be separated from:
(A) Main effects
(B) Two-way interactions
(C) Block effects
(D) Treatment sum of squares

2016

67. Partial confounding allows the recovery of information on the confounded effect by:
(A) Confounding different interactions across replications.
(B) Completely removing blocking variables from the design layout.
(C) Implementing a completely randomized design layout in the field.
(D) Applying appropriate transformations directly to the raw data.

2017

68. The layout of a Split-plot design differs from a standard factorial RBD because:
(A) Randomization of sub-plot treatments strictly dictates main-plot trials.
(B) The layout does not require any form of replication across blocks.
(C) All treatment combinations are randomized completely and simultaneously.
(D) Main plots are larger units while sub-plots are smaller divisions.

2019

69. A Split-plot design is most appropriate when:
(A) Both evaluated factors require small, highly uniform plot sizes.
(B) One factor requires a larger plot size than the other factor.
(C) The total number of treatments in the experiment is extremely low.
(D) The experimental field is completely homogeneous in all directions.

2025

70. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In a Split-plot design, the main-plot treatments are evaluated with less precision than the sub-plot treatments.
Reason (R): Main-plot error has fewer degrees of freedom and a larger error variance compared to sub-plot error.
(A) Both A and R are true and R is the correct explanation of A.

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(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018
71. How many error terms are computed in the ANOVA of a standard Split-plot design?
(A) One
(B) Two
(C) Three
(D) Four

2021
72. Error (a) in a Split-plot design represents the variability:
(A) Among main plots within a block.
(B) Among sub-plots within a main plot.
(C) Due to the interaction between main and sub-plot treatments.
(D) Across different replications for sub-plots.

2019
73. A Strip-plot (split-block) design is chosen over a Split-plot design when:
(A) Both factors can be easily managed within very small plots.
(B) Both factors require large plots for operational ease.
(C) There is absolutely zero interaction expected between factors.
(D) The experimental field lacks any fertility gradient entirely.

2001
74. In a Strip-plot design, the number of distinct error terms in the ANOVA is:
(A) One single overarching error term.
(B) Two distinct error terms.
(C) Three distinct error terms.
(D) Four distinct error terms.

2006
75. Match the experimental designs (List I) with their error structures (List II):
List I: (Experimental Design)
P. Completely Randomized Design
Q. Randomized Block Design
R. Split-plot Design
S. Strip-plot Design
List II: (Error Structure)
1. Two distinct error terms
2. One error term partitioned after removing blocks
3. Three distinct error terms
4. One overarching error term without blocking

(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-3, S-1
(C) P-1, Q-3, R-4, S-2
(D) P-4, Q-1, R-2, S-3

2015
76. The relative efficiency of an RBD compared to a CRD is assessed to determine:
(A) The optimal number of treatments to include in the design.
(B) Whether a data transformation is strictly necessary for analysis.
(C) Whether blocking reduced error variance.
(D) The physical size of the main experimental plots required.

2002
77. If the relative efficiency of RBD to CRD is 150%, it implies that:
(A) RBD requires fifty percent more replicates than CRD for precision.
(B) The error variance of the RBD is exactly 1.5 times that of CRD.
(C) Blocking was completely ineffective at reducing error variance.
(D) CRD needs 1.5 times more replicates for equal precision.

NODIA

2016
78. In intercropping experiments, the Land Equivalent Ratio (LER) is defined as:
(A) The direct ratio of total intercrop yield to the total land area utilized.
(B) The absolute difference in harvested yield between two competitive crops.
(C) The sum of relative yields of component crops to sole crops.
(D) The estimated percentage of overall land saved by applying fertilizer.

2017
79. An LER value greater than 1.0 indicates:
(A) Yield disadvantage of intercropping.
(B) Yield advantage of intercropping.
(C) Neutral effect of intercropping.
(D) Total failure of one component crop.

2021
80. Consider the following statements about Area Time Equivalent Ratio (ATER):
I. It accounts for the time crops spend in the field.
II. It is always equal to LER.
III. It provides a more realistic comparison when component crops differ significantly in duration.

I. It requires expected frequencies to be at least 5.
II. It is used to test continuous variables exclusively.
III. It compares observed and theoretical frequencies.

Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2022

41. In a 2×2 contingency table, the degrees of freedom for the Chi-square test of independence are:
(A) 4
(B) 3
(C) 2
(D) 1

2022

42. Yates' correction for continuity is applied to the Chi-square test when:
(A) The total sample size of the contingency table exceeds 500.
(B) Degrees of freedom equal 1 and expected values are small.
(C) There are more than three distinct columns in the frequency table.
(D) The underlying raw data is proven to be perfectly distributed.

2023

43. Which fundamental principle of experimental design provides an estimate of experimental error?
(A) Replication
(B) Randomization
(C) Local control
(D) Transformation

2012

44. The principle of local control aims to:
(A) Ensure all treatments receive identical randomized plots.
(B) Increase the total degrees of freedom for treatments.
(C) Reduce error by grouping homogeneous units.
(D) Eliminate the presence of any missing plots in the field.

2004

45. Randomization guarantees that:
(A) Experimental error in the design is completely reduced to zero.
(B) The treatment means of all groups are perfectly homogeneous.
(C) Local control measures become entirely unnecessary in the trial.
(D) All units have equal chance of receiving any treatment.

2023

46. Which experimental design utilizes only randomization and replication without local control?
(A) The standard Randomized Block Design.
(B) The standard Latin Square Design.
(C) Completely Randomized Design.
(D) The standard Split-plot Design.

2014

47. CRD is most appropriate when experimental units are:
(A) Highly heterogeneous in one direction
(B) Completely homogeneous
(C) Heterogeneous in two mutually perpendicular directions
(D) Divided into main plots and sub-plots

2024

48. If an experiment uses a CRD with 5 treatments, and each treatment is replicated 4 times, the total degrees of freedom will be:
(A) 15
(B) 16
(C) 19
(D) 20

2014

49. In a CRD, if treatment sum of squares is 40 (df = 4) and error sum of squares is 60 (df = 15), what is the F-ratio?
(A) 0.67
(B) 1.5
(C) 2.5
(D) 4.0

2013

50. Consider the following statements about Randomized Block Design (RBD):
I. It employs one-way local control.
II. Blocks are formed parallel to the fertility gradient.
III. The number of plots in a block equals the number of treatments.
IV. It can accommodate varying numbers of replications per block.

Which of the above statements are incorrect?
(A) I and II

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(C) Mode = Mean − Median
(D) Mode = 3 Mean − 2 Median

2018
92. The mean absolute deviation is minimal when taken from the:
(A) Arithmetic mean.
(B) The modal value.
(C) Median.
(D) The value zero.

2008
93. If the variance of a variable X is 25, the standard deviation is:
(A) 2.5
(B) 5
(C) 12.5
(D) 625

2015
94. Multiplying every value in a dataset by a constant k causes the standard deviation to be multiplied by:
(A) k
(B) k^2
(C) $\sqrt{k}$
(D) 1 (unchanged)

2004
95. The coefficient of variation is a unitless measure because:
(A) It utilizes transformed data values exclusively in the process.
(B) It divides the standard deviation by the mean.
(C) It squares any negative difference values within calculations.
(D) It corrects for the total degrees of freedom in the sample.

2004
96. Standard error of the mean decreases as sample size:
(A) Decreases
(B) Approaches zero
(C) Remains constant
(D) Increases

2023
97. A narrow confidence interval for a population mean indicates:
(A) Low standard error and high precision.
(B) High standard error and low precision.
(C) The sample size is extremely small.
(D) The population variance is infinite.

2006
98. In linear regression $Y = a + bX$, the parameter a represents the:
(A) Slope of the regression line
(B) Correlation coefficient
(C) Y-intercept
(D) Residual error

2006
99. The slope of a regression line (b) expresses the:
(A) Expected change in Y per unit change in X
(B) The total variance of the dependent variable Y.
(C) The physical intercept located on the X -axis.
(D) The extent of any non-linear relationship present.

2016
100. Consider the following statements about simple linear regression:
I. It minimizes orthogonal errors.
II. The line always passes through the point (mean X, mean Y).
III. The independent variable is considered fixed or measured without error.
IV. It can perfectly predict Y for any value of X
Which of the above statements are incorrect?
(A) I and II
(B) II and III
(C) I and IV
(D) III and IV

NODIA

2019
101. Which coefficient helps decide whether an independent variable significantly contributes to predicting a dependent variable?
(A) Correlation coefficient
(B) Regression coefficient
(C) Coefficient of variation
(D) Dispersion index

2014
102. When testing the hypothesis that population correlation $\rho = 0$, the sampling distribution of the test statistic is:
(A) The standard normal distribution.
(B) The Chi-square probability distribution.
(C) Student's t-distribution.
(D) The standard F-distribution.

2008
103. If two variables X and Y are completely independent, the expected correlation coefficient is:
(A) -1.0

(A) 19
(B) 20
(C) 21
(D) Cannot be determined

2022

149. The harmonic mean is particularly useful for averaging:
(A) Biological counts
(B) Rates, prices, and speeds
(C) Logarithmic growth phases
(D) Ordinal survey responses

2017

150. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R).
Assertion (A): Variance is universally preferred over the range as a measure of dispersion in statistical analysis.
Reason (R): Variance utilizes every observation in the dataset, providing a more reliable measure of spread than the range.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

151. Which measure of central tendency is undefinable if any dataset value is zero?
(A) Arithmetic Mean
(B) Median
(C) Mode
(D) Harmonic Mean

2010

152. The square of the standard error of the mean is equal to:
(A) Variance divided by sample size.
(B) Variance multiplied by sample size.
(C) Standard deviation divided by sample size.
(D) Sample size divided by variance.

2001

153. A coefficient of variation of 0% implies that:
(A) The calculated sample mean is exactly zero.
(B) All observations in the sample are identical.
(C) The overall standard deviation is infinite.
(D) The total experimental sample size is one.

2003

154. If two variables consistently move in opposite directions at a constant rate, their correlation coefficient is:
(A) +1.0
(B) -1.0
(C) 0.0
(D) -0.5

2004

155. Match the concept in regression in List I with its defining characteristic in List II:
List I: Concept
P. Independent variable
Q. Dependent variable
R. Intercept
S. Residual
List II: Characteristic
1. Difference between observed and predicted values
2. The predictor variable set by the researcher
3. The response variable being estimated
4. The value of Y when X equals zero
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-1, Q-4, R-3, S-2
(D) P-2, Q-1, R-4, S-3

2010

156. In the regression equation $Y = a + bX$, if $b = 0$, the regression line is:
(A) Parallel to the Y-axis
(B) A 45-degree line passing through the origin
(C) Parallel to the X-axis
(D) Undefined

2015

157. A high coefficient of determination ($R^2 \approx 0.95$) suggests that:
(A) The dependent variable directly causes changes in the independent factor.
(B) Exactly 95% of the raw data points fall directly on the regression line.
(C) The regression model is strictly non-linear and requires curve fitting.
(D) The model explains 95% of the variation in the dependent variable.

2018

158. The degrees of freedom for the total sum of squares in a dataset with n observations is:
(A) n
(B) $n-1$
(C) $n-2$
(D) $n+1$

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P. Null hypothesis
Q. Type II error
R. Level of significance
S. Power of a test

List II: Definition

1. Probability of rejecting a true null hypothesis
2. Hypothesis of no difference
3. Probability of rejecting a false null hypothesis
4. Failing to reject a false null hypothesis

(A) P-2, Q-4, R-1, S-3
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-2, S-1
(D) P-1, Q-2, R-3, S-4

2005

116. Yates' correction for continuity reduces the calculated Chi-square value by adjusting the absolute difference between observed and expected frequencies by:
(A) 0.5
(B) 1.0
(C) 1.5
(D) 2.0

2014

117. In a completely randomized design, the experimental error arises strictly from:
(A) Variations introduced systematically among different treatments.`
(B) Variations among experimental units within the same treatment.`
(C) Block-to-block variation across different replication groups.`
(D) Missing data estimation errors occurring during data analysis.`

2005

118. Which experimental design provides the maximum degrees of freedom for estimating experimental error?
(A) Randomized Block Design
(B) Latin Square Design
(C) Completely Randomized Design
(D) Split-plot Design

2022

119. A major disadvantage of CRD is that:
(A) Statistical analysis becomes highly complex with missing observations.
(B) It strictly requires an equal number of replications for all treatments.
(C) Missing data points completely invalidate the entire statistical analysis.
(D) It is highly inefficient for heterogeneous areas lacking local control.

2007

120. Consider the following statements about missing plot techniques:
I. They recover the exact true value of the lost observation.
II. They minimize the error sum of squares.
III. They necessitate a reduction in error degrees of freedom.
IV. They restore orthogonality to the design.
V. They are applicable only in CRD.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and IV
(C) III, IV and V
(D) I, IV and V

2003

121. In an RBD, if a fertility gradient is recognized along a slope, blocks should be laid out:
(A) Parallel to the slope.
(B) Perpendicular to the slope.
(C) Randomly without regard to the slope.
(D) Alternating parallel and perpendicular.

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2017

122. The efficiency of a blocking design is indicated by a large mean square for:
(A) Error
(B) Blocks
(C) Treatments
(D) Total

2025

123. If treatments are arranged sequentially (e.g., T1, T2, T3) in every block of an experiment rather than randomly, the design violates Fisher's principle of:
(A) Randomization
(B) Replication
(C) Local control
(D) Confounding

2010

124. The term "degrees of freedom" generally refers to the number of:
(A) Total number of experimental observations in the study.
(B) Treatment groups minus the total number of replications.
(C) Independent values in a sample free to estimate a parameter.
(D) Total blocks or group divisions in an experimental layout.

error.

2002

196. The expected frequency for a cell in a contingency table under the null hypothesis of independence is:

(A) $\frac{\text{Row Total} + \text{Column Total}}{\text{Grand Total}}$

(B) $\frac{\text{Grand Total}}{\text{Row Total} \times \text{Column Total}}$

(C) Row Total $\times$ Column Total

(D) $\frac{\text{Row Total} \times \text{Column Total}}{\text{Grand Total}}$

2005

197. Replication in experimental design serves primarily to:
(A) Simplify the ANOVA table.
(B) Provide an estimate of experimental error.
(C) Guarantee that all treatments are effective.
(D) Reduce the degrees of freedom.

2024

198. In a CRD, the analysis of variance relies entirely on partitioning the total variation into:
(A) Treatments and Blocks
(B) Blocks and Error
(C) Treatments and Error
(D) Treatments, Blocks, and Error

2009

199. An RBD requires that every block contains:
(A) A random fraction of the treatments.
(B) At least one missing plot.
(C) All treatments applied twice.
(D) All treatments applied exactly once.

2022

200. Calculating a missing plot estimate in an RBD causes a slight upward bias in the treatment sum of squares, which is mathematically handled by:
(A) Correcting the treatment sum of squares.
(B) Adjusting the block sum of squares down.
(C) Doubling the experimental error variance.
(D) Ignoring the missing plot in calculations.

2021

201. Which transformation technique normalizes proportional data spanning from 0% to 100%?
(A) Logarithmic
(B) Arcsine
(C) Square root
(D) Tangent

2015

202. A factorial design exploring all combinations of 3 levels of Nitrogen and 2 levels of Phosphorus has how many unique treatment combinations?
(A) 5
(B) 6
(C) 8
(D) 9

2012

203. The defining characteristic of a confounded factorial design is the intentional mixing of treatment effects with:
(A) Block effects
(B) Main effects
(C) Replication effects
(D) Error terms

2017

204. In a Split-plot design evaluating irrigation methods (Main plots) and fertilizer levels (Sub-plots), randomization of fertilizer levels occurs:
(A) Randomly across the entire field area.
(B) Across different replication groups only.
(C) Independently within each main plot area.
(D) Without any structured systematic process.

2010

205. The primary disadvantage of a Strip-plot design compared to a Split-plot design is:
(A) Greater difficulty in field operations.
(B) Total inability to measure interactions.
(C) Complete lack of ANOVA methodologies.
(D) Lower precision for both main effects.

2013

206. Relative efficiency calculations typically express precision as a ratio of:
(A) Degrees of freedom for experimental error.
(B) Partitioned sums of squares for treatments.
(C) Inverse error variances of the two designs.
(D) Treatment block means across replications.

2023

207. A mixed intercropping system LER of 1.25 indicates a land saving of:
(A) 12.5%
(B) 20%
(C) 25%
(D) 125%

2011

208. When performing a pooled analysis of variance, data from different environments should be pooled only if the environments have:
(A) Significantly different block structures.
(B) Differing numbers of replications.

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(C) Split-plot Design
(D) Split-split-plot Design

2012
138. Strip-plot designs are uniquely beneficial for agricultural trials involving:
(A) Controlled greenhouse pot experiments requiring uniform settings.
(B) Factors requiring large plots like tillage and irrigation.
(C) Single-factor varietal evaluations under uniform crop management.
(D) Fully homogeneous soil conditions with minimal field variations.

2021
139. In evaluating Relative Efficiency, if $RE > 1$, it demonstrates that:
(A) The test design is more precise than the base design.
(B) The test design is less precise than the base design.
(C) Both designs have equal precision.
(D) The base design has zero error.

2022
140. Land Equivalent Ratio (LER) relies on the yield of intercrops compared to:
(A) The average regional yield of those crops over multiple seasons.
(B) The theoretical maximum yield potential under perfect conditions.
(C) Respective sole crop yields evaluated under identical management.
(D) The total biomass yield of the most dominant weed in the field.

2002
141. The Competitive Ratio (CR) index in intercropping measures:
(A) Total protein output per hectare produced by both component crops.
(B) The exact number of days both crops overlap in their growth cycles.
(C) The financial ratio of crop selling prices in local retail markets.
(D) Ratio of LER of the two crops, adjusted for sown proportions.

2014
142. A Bartlett's test yielding a significant p-value (< 0.05) indicates that:
(A) Error variances are homogeneous across environments.
(B) Treatment means are identical.
(C) Error variances are heterogeneous across environments.
(D) The multi-location trial is invalid.

2023
143. When error variances are heterogeneous in multi-environment trials, a common remedial measure before pooled ANOVA is:
(A) Discarding all data from the highest yielding location.
(B) Performing data transformation or using weighted ANOVA.
(C) Ignoring the heterogeneity and running regular ANOVA.
(D) Converting all data to binary responses.

2003
144. The degrees of freedom for the Genotype $\times$ Environment interaction in a pooled ANOVA across l locations and g genotypes is:
(A) $l \cdot g - 1$
(B) $l(g-1)$
(C) $g(l-1)$
(D) $(l-1)(g-1)$

2022
145. A continuous variable can be accurately described as one that:
(A) Assumes any numerical value within an interval.
(B) Represents distinct, non-overlapping categories.
(C) Reflects ordinal rankings only.
(D) Cannot be measured with a metric scale.

2001
146. Which graphical representation is most suitable for displaying a continuous frequency distribution?
(A) Bar chart
(B) Pie chart
(C) Histogram
(D) Scatter plot

2002
147. A cumulative frequency curve is also referred to as an:
(A) Ogive
(B) Isoline
(C) Asymptote
(D) Envelope

2017
148. The arithmetic mean of 10 observations is 20. If one observation (20) is removed, the new mean becomes:

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2002

125. The transformation $\log(X+1)$ is preferred over $\log(X)$ when the dataset contains:
(A) Percentages near 100
(B) Negative numbers
(C) Extreme outliers
(D) Zero values

2025

126. A non-parametric alternative to the paired t-test is the:
(A) Kruskal-Wallis test
(B) Mann-Whitney U test
(C) Wilcoxon signed-rank test
(D) Spearman rank test

2017

127. Which transformation is required when data follows a binomial distribution with proportions ranging heavily near 0 and 1?
(A) Square root
(B) Arcsine
(C) Logarithmic
(D) Reciprocal

2013

128. An experiment evaluating 3 nitrogen levels and 4 phosphorus levels simultaneously in all combinations is an example of a:
(A) Strip-plot experiment
(B) Confounded experiment
(C) Simple randomized block
(D) Factorial experiment

2007

129. If interaction $A \times B$ is significant in a factorial ANOVA, the researcher should primarily focus on interpreting:
(A) Simple effects of one factor across levels of the other.
(B) Main effect of factor A completely ignoring factor B.
(C) Main effect of factor B completely ignoring factor A.
(D) Block effects across different replication environments.

2010

130. A symmetrical factorial experiment is one in which:
(A) The number of factors equals the number of replications.
(B) Error variance equals treatment variance.
(C) All factors have the same number of levels.
(D) No main effects are significant.

2005

131. In a 2^2 factorial experiment, the levels of factors are typically designated as:
(A) High and low (e.g., 0 and 1)
(B) 1, 2, 3, and 4
(C) Main and sub
(D) Positive and negative variance

2010

132. The process of dividing a full replicate of a factorial experiment into smaller blocks, thereby mixing a treatment effect with block differences, is known as:
(A) Randomization
(B) Blocking
(C) Splitting
(D) Confounding

2014

133. Which effect is most frequently chosen to be confounded in higher-order factorial experiments?
(A) Main effects
(B) Highest-order interaction
(C) First-order interactions
(D) Block effects

2004

134. Complete confounding implies that the same interaction is confounded in:
(A) Only one replication.
(B) Half of the replications.
(C) All the replications.
(D) None of the replications.

2011

135. In a Split-plot design, degrees of freedom for Error (a) are typically calculated as:
(A) $(r-1)(s-1)$
(B) $m(r-1)(s-1)$
(C) $r(m-1)(s-1)$
(D) $(r-1)(m-1)$

2002

136. The precision of comparison for main-plot treatments in a Split-plot design is:
(A) Lower than sub-plot treatments.
(B) Higher than sub-plot treatments.
(C) Exactly equal to sub-plot treatments.
(D) Independent of replication number.

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2003

137. Which experimental design introduces two-way randomization of treatments perpendicularly across the entire block?
(A) Latin Square Design
(B) Strip-plot Design

2006
159. Statistical power is mathematically maximized by:
(A) Decreasing the sample size.
(B) Increasing the sample size.
(C) Lowering the level of significance from 0.05 to 0.01.
(D) Increasing the variability of the data.

2022
160. For testing the significance of a single sample mean against a known population mean when the population variance is unknown and sample size is small, use:
(A) One-sample Z-test
(B) Chi-square goodness of fit test
(C) Analysis of Variance
(D) One-sample t-test

2024
161. An assumption of the independent two-sample t-test is that the two populations have:
(A) Normal distributions and equal variances.
(B) Different means but known standard errors.
(C) Equal sizes.
(D) Zero variances.

2002
162. ANOVA is fundamentally a procedure for testing the equality of several:
(A) Variances
(B) Correlation coefficients
(C) Means
(D) Proportions

2018
163. The sum of expected frequencies in a Chi-square goodness of fit test must always equal:
(A) The total observed frequencies.
(B) Exactly 1.0 in all conditions.
(C) Exactly 100 in percentage tests.
(D) The designated degrees of freedom.

2011
164. Which of Fisher's principles controls known sources of variation?
(A) Randomization
(B) Replication
(C) Confounding
(D) Local control

2001
165. The primary advantage of a Completely Randomized Design (CRD) is its:
(A) Complex mathematical calculations.
(B) Maximum error degrees of freedom.
(C) Ability to control soil gradients.
(D) Requirement of minimal treatments.

2018
166. A Randomized Block Design (RBD) handles site heterogeneity by grouping units into blocks such that:
(A) Intra-block variance is maximized and inter-block variance is minimized.
(B) Both intra-block and inter-block variances are maximized.
(C) Intra-block variance is minimized and inter-block variance is maximized.
(D) Both intra-block and inter-block variances are minimized.

2014
167. Missing plot techniques strictly require that the estimated value:
(A) Increases the treatment sum of squares.
(B) Maximizes the total sum of squares.
(C) Eliminates the block effects.
(D) Minimizes the error sum of squares.

2005
168. If two missing values occur in an RBD, they are estimated using:
(A) Iterative calculation steps until estimates converge.
(B) Simple arithmetic average of all remaining plots.
(C) Complete exclusion of affected treatment combinations.
(D) Assignment of zero values directly to missing plots.

2007
169. Data requiring a square root transformation typically exhibit a variance that is:
(A) Independent of the mean.
(B) Proportional to the mean.
(C) Proportional to the mean squared.
(D) Equal to zero.

2025
170. Which logarithmic transformation base is conventionally used in agricultural statistics for variance stabilization?
(A) Base 2 binary logarithm.
(B) Base 10 or natural log.
(C) Base 16 hex logarithm.
(D) Base 0.5 fractional log.

2010
171. A major reason to run a factorial experiment instead of separate single-factor experiments is to:

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(B) 0.0
(C) 0.5
(D) 1.0

2006
104. Spearman's rank correlation handles tied ranks by:
(A) Assigning average ranks to tied values.
(B) Completely deleting any tied observations.
(C) Giving the lowest rank to all tied values.
(D) Giving the highest rank to all tied values.

2011
105. Arrange the following critical steps for conducting an ANOVA in the proper sequence:
I. Compute the Error Sum of Squares.
II. Compute the Correction Factor.
III. Compute the Total Sum of Squares.
IV. Compute the Treatment Sum of Squares.
(A) II, III, IV, I
(B) I, II, III, IV
(C) III, IV, II, I
(D) II, IV, III, I

2013
106. In an ANOVA table, Mean Square is obtained by dividing the Sum of Squares by:
(A) Total number of observations
(B) Degrees of freedom
(C) Number of treatments
(D) Number of replicates

2012
107. The null hypothesis in a one-way ANOVA states that:
(A) All population means are equal.
(B) All population variances are equal.
(C) At least one population mean is different.
(D) The sample means are equal to zero.

2010
108. An alternative hypothesis that specifies the direction of the expected difference (e.g., $\text{mean}_1 > \text{mean}_2$) requires a:
(A) Two-tailed test
(B) Chi-square test
(C) One-tailed test
(D) Goodness of fit test

2008
109. Decreasing the level of significance (e.g., from 0.05 to 0.01) makes it:
(A) Easier to reject the null hypothesis.
(B) Certain to accept the alternative hypothesis.
(C) Impossible to commit a Type II error.
(D) Harder to reject the null hypothesis.

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2004
110. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R).
Assertion (A): In hypothesis testing, $p-\text{value} < 0.05$ implies we reject the null hypothesis at the 5% level of significance.
Reason (R): The p-value indicates the exact probability that the null hypothesis is true.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018
111. The paired t-test assumes that the differences between paired observations are:
(A) Uniformly distributed
(B) Normally distributed
(C) Binomially distributed
(D) Exponentially distributed

2012
112. When sample size increases, the t-distribution curve:
(A) Becomes progressively flatter and much wider.
(B) Skews heavily to the right side of the axis.
(C) Loses its characteristic bell-shaped symmetry.
(D) Approximates the standard normal distribution.

2016
113. The critical value for an F-test depends on two sets of degrees of freedom corresponding to:
(A) Numerator and denominator mean squares.
(B) Total and experimental error mean squares.
(C) Treatment factors and block variation totals.
(D) Replications and overall grand population mean.

2021
114. For testing the goodness of fit of a genetic ratio 3:1 in a cross, the appropriate test is:
(A) t-test
(B) ANOVA
(C) Chi-square test
(D) Correlation test

2011
115. Match the concept in List I with its definition in List II:
List I: Concept

2006
183. Grouping data into class intervals inevitably results in:
(A) Automatic increase in the standard deviation.
(B) Perfect normal distribution of the dataset.
(C) Elimination of all extreme statistical outliers.
(D) Loss of original data identity and precision.

2024
184. The difference between the upper limit and the lower limit of a class is termed the:
(A) Class width or magnitude
(B) Class frequency
(C) Class mark
(D) Class interval boundary

2007
185. If a distribution has an extended tail to the left, its skewness is:
(A) Positive
(B) Negative
(C) Zero
(D) Symmetrical

2010
186. Standard deviation is preferred over variance for reporting descriptive statistics because:
(A) It completely avoids squaring raw values.
(B) It shares the original units of measurement.
(C) It is mathematically less than variance.
(D) It is highly robust to extreme outliers.

2004
187. The Coefficient of Variation is calculated as:
(A) $\left(\frac{\sigma}{\mu}\right) \times 100$
(B) $\left(\frac{\mu}{\sigma}\right) \times 100$
(C) $\left(\frac{\sigma^2}{\mu}\right) \times 100$
(D) $\left(\frac{\mu^2}{\sigma}\right) \times 100$

2017
188. If two variables lack any relationship, a scatter plot of their values will roughly resemble:
(A) A straight linear line.
(B) A symmetrical parabola.
(C) A random cloud of points.
(D) A perfect geometric circle.

2021
189. Correlation coefficient r is independent of changes in:
(A) Origin only.
(B) Scale only.
(C) Neither origin nor scale.
(D) Both origin and scale.

2005
190. In simple linear regression, the point defined by the arithmetic mean of X and the arithmetic mean of Y:
(A) Lies significantly below the regression line.
(B) Lies significantly above the regression line.
(C) Lies precisely on the fitted regression line.
(D) Represents the y-intercept of the regression.

2009
191. If the true population coefficient of determination is zero, the expected F-ratio in regression ANOVA is approximately:
(A) 0
(B) 1
(C) Infinite
(D) Negative

2008
192. Which statistical error is considered more serious when testing the safety of a new agrochemical (where null hypothesis = chemical is unsafe)?
(A) Type II error
(B) Standard error
(C) Sampling error
(D) Type I error

2008
193. The critical value of a test statistic denotes the boundary that separates the:
(A) Acceptance region from the rejection region.
(B) Variance from the standard deviation.
(C) Null hypothesis from the data.
(D) Error mean square from treatment mean square.

2023
194. Which assumption is fundamental for applying an independent two-sample t-test?
(A) Observations are paired by time.
(B) The population variances are significantly different.
(C) Observations between groups are independent.
(D) The sample sizes must be unequal.

2024
195. A large F-ratio in ANOVA indicates that the variation among treatment means is:
(A) Larger than the variation within treatments.
(B) Smaller than the variation within treatments.
(C) Exactly equal to variation within treatments.
(D) Purely attributed to random experimental

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(A) Evaluate interaction effects between factors.
(B) Avoid randomization requirements in the field.
(C) Reduce the degrees of freedom for pooled error.
(D) Simplify the layout and management of plots.

2003
172. The interaction sum of squares in a two-factor experiment (Factors A and B) is computed by subtracting the main effects of A and B from the:
(A) Overall replication block sum of squares.
(B) Overall corrected total sum of squares.
(C) Treatment combinations sum of squares.
(D) Experimental residual error sum of squares.

2019
173. The primary drawback of full factorial designs with many factors is:
(A) Inability to test main effects of primary factors.
(B) Complete failure of standard ANOVA computations.
(C) Strict requirement for homogeneous field conditions.
(D) Exponential growth in treatment combinations.

2017
174. Confounding is generally applied to experiments with a large number of treatments because it:
(A) Eliminates high-order interactions from model.
(B) Increases the total experimental error variance.
(C) Reduces block size to maintain unit homogeneity.
(D) Allows investigators to bypass randomization.

2019
175. In a Split-plot design, the main plot error (Error a) typically has:
(A) More degrees of freedom than the sub-plot error (Error b).
(B) Fewer degrees of freedom than the sub-plot error (Error b).
(C) Degrees of freedom equal to the total number of blocks.
(D) Zero degrees of freedom.

2001
176. Which plot in a Split-plot design receives the treatment that requires larger application machinery, such as irrigation or tillage?
(A) Sub-plot
(B) Interaction plot
(C) Guard row
(D) Main plot

2021
177. A Strip-plot design provides the highest precision for estimating:
(A) Interaction effect between the two factors.
(B) Main effect of the horizontal factor only.
(C) Main effect of the vertical factor only.
(D) Block effects across the replication blocks.

NODIA

2017
178. The precision of an experimental design is mathematically inversely proportional to its:
(A) Degrees of freedom
(B) Total sum of squares
(C) Error variance
(D) Treatment variance

2025
179. In evaluating multiple cropping systems, ATER stands for:
(A) Area Time Equivalent Ratio
(B) Annual Total Efficiency Ratio
(C) Agronomic Treatment Error Rate
(D) Absolute Time Evaluation Ratio

2003
180. A competitive ratio (CR) greater than 1.0 for crop A relative to crop B implies that:
(A) Crop A is less competitive than crop B.
(B) Crop A and crop B are equally competitive.
(C) Crop A failed to emerge.
(D) Crop A is more competitive than crop B.

2008
181. Why is Bartlett's test highly sensitive?
(A) It requires a large minimum number of research locations.
(B) It is highly sensitive to departures from normality.
(C) It only handles comparisons of two groups at any time.
(D) It strictly requires equal error variances initially.

2023
182. A qualitative variable categorizes data into groups based on:
(A) Exact numerical measurements.
(B) Precise fractional components.
(C) Distinct attributes or labels.
(D) Total cumulative frequencies.

(C) Unrelated treatments.
(D) Homogeneous error variances.

2005

209. If Bartlett's test confirms heterogeneity of variances across 5 locations, the most statistically sound approach for combined analysis is to:
(A) Perform a weighted ANOVA using error variances.
(B) Proceed with standard pooled ANOVA regardless.
(C) Delete the lowest-yielding location from trials.
(D) Change the experimental design retrospectively.

2002

210. Which index describes the yield of an intercrop expressed as a proportion of its yield as a sole crop?
(A) Aggressivity Index
(B) Competitive Ratio
(C) Relative Yield
(D) Relative Crowding Coefficient

****

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measures represent the value that divides an ordered dataset into two equal halves, such that fifty percent of the observations fall below this point and fifty percent of the observations lie above it.

90. (A) III, I, II, IV
Calculating the variance of grouped data begins by finding the midpoints of the class intervals. Next, the deviations of these midpoints from the mean are calculated. These squared deviations are then multiplied by class frequencies, and finally, the products are summed and divided by the total frequency minus one.

91. (A) Mode $= 3\,\text{Median} - 2\,\text{Mean}$
In a moderately asymmetrical distribution, there is a reliable empirical relationship between the three measures of central tendency. This relationship is mathematically expressed as the mode being equal to three times the median minus two times the arithmetic mean, helping estimate a missing measure when two are known.

92. (C) Median.
The mean absolute deviation, which is the average of the absolute values of the differences between data points and a central value, is minimized when those deviations are calculated from the median. Taking deviations from any other value, including the mean or mode, results in a larger sum.

93. (B) 5
The standard deviation is mathematically defined as the positive square root of the variance. Therefore, if the variance of a variable X is equal to twenty-five, taking the square root of this value yields a standard deviation of exactly five, which is expressed in the original measurement units.

94. (A) k
Multiplying every observation in a dataset by a constant k scales the entire distribution. Consequently, the standard deviation, which is a linear measure of dispersion, is also multiplied by the absolute value of that constant k, whereas the variance of the dataset would be multiplied by k squared.

95. (B) It divides the standard deviation by the mean.
The coefficient of variation is a dimensionless, unitless measure of relative variability. It achieves this property because it is calculated by dividing the sample standard deviation by the sample mean. Since both parameters share the same physical units, the units cancel out, leaving a pure ratio often expressed as a percentage.

96. (D) Increases
The standard error of the mean is inversely proportional to the square root of the sample size. As the sample size increases, the standard error decreases. This mathematical relationship demonstrates that taking larger samples reduces the variability of the sample mean, leading to more precise estimates of the population mean.

NODIA

97. (A) Low standard error and high precision.
A narrow confidence interval for a population mean indicates that the estimate has high precision and low standard error. A smaller standard error reduces the margin of error, narrowing the interval and providing greater confidence that the sample mean is very close to the true population parameter.

98. (C) Y-intercept
In the simple linear regression equation Y equals a plus bX, the parameter a represents the Y -intercept. This value indicates the expected or predicted value of the dependent variable Y when the independent variable X is equal to zero, establishing the starting position of the regression line.

99. (A) Expected change in Y per unit change in X.
The slope of a regression line, represented by the parameter b, expresses the expected change in the dependent variable Y for every one-unit increase in the independent variable X. A positive slope indicates a direct relationship, while a negative slope indicates an inverse relationship between the two analyzed variables.

100. (C) I and IV
Simple linear regression minimizes the sum of vertical squared residuals rather than orthogonal errors. Additionally, while the model estimates the average linear relationship, it cannot perfectly predict Y for any value of X due to the presence of random error, meaning that both the first and fourth statements are incorrect.

101. (B) Regression coefficient
The regression coefficient represents the rate of change in the dependent variable per unit change in the independent variable. Testing

11. (A) Standard deviation
Standard deviation is expressed in the exact same physical units as the original observations because it is calculated by taking the square root of the variance. This property makes it highly interpretable, unlike variance, which is expressed in squared units, and relative measures like the coefficient of variation, which are dimensionless.

12. (C) Remain unchanged
Adding a constant to every observation in a dataset shifts the entire distribution along the measurement axis without altering the relative distances between any data points. Since the spread and dispersion of the values remain completely identical, the variance of the transformed dataset stays unchanged from its original value.

13. (D) SD measures sample variation while SE measures mean precision.
Standard deviation measures the dispersion or spread of individual observations around the sample mean, reflecting the natural variability within a sample. In contrast, the standard error of the mean measures the precision of the sample mean as an estimate of the true population mean, quantifying sampling variability across trials.

14. (C) $\frac{s}{\sqrt{n}}$
The standard error of the mean represents the standard deviation of the sampling distribution of the mean. It is mathematically calculated by dividing the sample standard deviation by the square root of the sample size. This division reflects how larger sample sizes increase the precision of the estimated population mean.

15. (B) Calculate mean → Calculate variance → Calculate standard deviation → Divide SD by mean and multiply by 100
Calculating the coefficient of variation requires finding the mean and the variance of the dataset first. The standard deviation is then obtained by taking the square root of the variance. Finally, dividing this standard deviation by the mean and multiplying by one hundred yields the final percentage, expressing relative variability.

16. (D) Experimental precision.
The coefficient of variation is a relative measure of dispersion that expresses the experimental error as a percentage of the overall mean. In agricultural field experiments, it serves as a primary diagnostic tool to evaluate experimental precision, with lower values indicating higher reliability and consistency of the trial.

17. (B) 10% to 15%
In agricultural field experiments, a coefficient of variation falling within the range of ten to fifteen percent typically indicates acceptable reliability and precision. Values below this range are rare due to environmental noise, whereas values above thirty percent suggest excessive variation, rendering the treatment comparisons unreliable and statistically weak.

18. (C) Zero or near-zero correlation
A scatter diagram in which the plotted data points spread widely and evenly across all four quadrants indicates that changes in one variable do not systematically correspond to changes in the other. This lack of any discernable linear pattern or trend signifies a zero or near-zero correlation between the variables.

19. (A) -1 and +1
Pearson's product-moment correlation coefficient is a standardized measure of the linear relationship between two variables, and its values are strictly bounded between negative one and positive one. A value of negative one indicates perfect negative correlation, positive one indicates perfect positive correlation, and zero indicates no linear relationship.

20. (A) II, III and V
Spearman's rank correlation is indeed a non-parametric measure, and Pearson's coefficient is highly sensitive to extreme outlying observations. Because correlation measures the linear association between two variables and does not imply direct causation, and a value of negative zero point eight five represents a strong relationship, only those three statements are correct.

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21. (B) Data follow a bivariate normal distribution.
Pearson's correlation coefficient is a parametric statistic that strictly requires the assumption that the analyzed variables follow a joint bivariate normal distribution in the population. Spearman's rank correlation coefficient is a non-parametric alternative that bypasses this assumption, depending instead on the monotonic relationship between the ranks of the data.

treatment differences for that interaction align perfectly with block boundaries, its sum of squares cannot be separated from the block sum of squares.

67. (A) Confounding different interactions across replications.
Partial confounding allows the recovery of some information on confounded interaction effects by confounding different interactions in different replications. For example, if a specific interaction is confounded in only one replicate but not in others, information about that interaction can still be estimated from the remaining unconfounded replicates.

68. (D) Main plots are larger units while sub-plots are smaller divisions.
The physical layout of a Split-plot design differs fundamentally from a standard factorial randomized block design because it features two distinct sizes of experimental units. The main plots are larger units assigned to one factor, while the sub-plots are smaller divisions within the main plots assigned to another factor.

69. (B) One factor requires a larger plot size than the other factor.
A Split-plot design is most appropriate when the experimental factors naturally require different plot sizes due to operational constraints. For example, tillage or irrigation methods require large main plots for machinery access, while fertilizer levels or crop varieties can be easily applied to smaller sub-plots within those areas.

70. (A) Both A and R are true and R is the correct explanation of A.
In a Split-plot design, main-plot treatments are evaluated with less precision than sub-plot treatments because main-plot comparisons are made across larger, more heterogeneous units. Additionally, the main-plot error term has fewer degrees of freedom and a larger error variance compared to the highly replicated sub-plot error term.

71. (B) Two
In the analysis of variance of a standard Split-plot design, exactly two separate error terms are calculated. Error A is used to test the significance of the main-plot factor, while Error B is used to test the significance of both the sub-plot factor and the main-plot by sub-plot interaction.

72. (A) Among main plots within a block.
Error A in a Split-plot design represents the experimental error associated with the main plots. It quantifies the background variability among the main plots within each block, serving as the appropriate denominator for testing the significance of the main-plot treatment effects in the analysis of variance.

73. (B) Both factors require large plots for operational ease.
A Strip-plot design is selected over a Split-plot design when both factors under evaluation require large plot sizes for ease of agricultural operations, such as plowing and harvesting. In this design, factors are applied in perpendicular strips across the blocks, creating a grid-like layout in the field.

74. (C) Three distinct error terms.
In a Strip-plot design, the analysis of variance calculates three distinct error terms. Error A is used to test the horizontal strip treatments, Error B is used to test the vertical strip treatments, and Error C is used to test the interaction effect between the horizontal and vertical treatments.

75. (A) P-4, Q-2, R-1, S-3
A completely randomized design uses one overarching error term, while a randomized block design has one error term after removing blocks. A split-plot design features two distinct error terms, and a strip-plot design has three distinct error terms, linking each experimental design with its correct error structure.

76. (C) Whether blocking reduced error variance.
The relative efficiency of a Randomized Block Design compared to a Completely Randomized Design is evaluated to determine whether grouping units into blocks was effective. It measures whether the reduction in error variance achieved by blocking outweighed the loss of error degrees of freedom associated with removing block effects.

77. (D) CRD needs 1.5 times more replicates for equal precision.
An RBD relative efficiency of one hundred and fifty percent compared to a CRD means that the CRD would require one point five times as many replications to achieve the exact same level of statistical precision. This demonstrates

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measurements on the same individuals. This design controls for subject-to-subject variability, thereby increasing the statistical power of the analysis.

34. (C) Pooled sample variance
When testing the difference between the means of two independent samples with unknown but equal population variances, the appropriate t-test statistic relies on the pooled sample variance. This pooled estimate combines the variances of both samples, weighted by their respective degrees of freedom, to provide a single, more precise variance estimate.

35. (A) P-4, Q-1, R-2, S-3
The paired t-test compares pre-treatment and post-treatment means, while the F-test evaluates the equality of two population variances. The Chi-square test assesses the goodness of fit for count data, whereas the Z-test is utilized for comparing means of large samples, linking each test statistic to its proper application.

36. (D) The ratio of the two sample variances
The F-test evaluates the hypothesis of equal population variances by calculating the ratio of the two independent sample variances. By convention, the larger sample variance is placed in the numerator, and the resulting ratio is compared against the critical value from the F -distribution to assess statistical significance.

37. (B) Treatment and error sums of squares.
In the Analysis of Variance, the total variation present in the experimental data, represented by the total sum of squares, is partitioned into distinct components. These components are the treatment sum of squares, which measures variations between treatments, and the error sum of squares, which measures unexplained random variations.

38. (C) $\dfrac{\text{Treatment Mean Square}}{\text{Error Mean Square}}$
The F-ratio in a one-way Analysis of Variance is calculated by dividing the treatment mean square by the error mean square. This ratio compares the variance between treatment groups to the variance within the groups, testing whether the treatment effects are significantly larger than the underlying experimental error.

39. (C) $t(r-1)$
In a completely randomized design with t treatments and r replications per treatment, the total degrees of freedom equal the total number of experimental units minus one. The treatment degrees of freedom are t minus one, leaving the remaining error degrees of freedom as the product of t and r minus one.

40. (C) I and III
The Chi-square goodness of fit test is a non-parametric test designed specifically for discrete count data rather than continuous variables. It requires that the expected frequency in each category be at least five to ensure accuracy, and it directly compares observed counts against theoretical, expected frequencies.

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41. (D) 1
The degrees of freedom for a Chi-square test of independence in a contingency table are calculated as the number of rows minus one multiplied by the number of columns minus one. For a two by two table, this calculation yields one, meaning there is only one independent cell in the table.

42. (B) Degrees of freedom equal 1 and expected values are small.
Yates' correction for continuity is applied to the Chi-square test of independence when there is only one degree of freedom and expected frequencies are small. The correction adjusts the formula by subtracting zero point five from the absolute difference between observed and expected frequencies, reducing overestimation of significance.

43. (A) Replication
Replication is the fundamental principle of experimental design that involves repeating the treatments on multiple experimental units. It is essential because it provides the only means of estimating the experimental error variance, which is required to perform tests of significance and construct confidence intervals for treatment differences.

44. (C) Reduce error by grouping homogeneous units.
The principle of local control involves grouping adjacent or similar experimental units into homogeneous blocks to account for known sources of variation, such as fertility gradients.

By keeping variation within blocks minimal, local control successfully reduces the experimental error variance, thereby increasing the precision and sensitivity of the experiment.

45. (D) All units have equal chance of receiving any treatment.
Randomization guarantees that every experimental unit has an equal and unbiased chance of receiving any of the allocated treatments. This principle ensures that the experimental errors are independent and identically distributed, which is a key assumption required for the validity of subsequent statistical tests and significance analyses.

46. (C) Completely Randomized Design.
The Completely Randomized Design is the simplest experimental layout that utilizes only the principles of randomization and replication, completely omitting local control. It is used when the experimental units are highly homogeneous, meaning there are no systematic environmental gradients or external factors requiring the formation of blocks.

47. (B) Completely homogeneous
A completely randomized design is most appropriate and efficient when the experimental units are completely homogeneous, such as in controlled greenhouse studies or laboratory environments. Because there is no direction of systematic soil or environmental variation, blocking is unnecessary, allowing all treatments to be randomized completely across all plots.

48. (C) 19
With five treatments and four replications, the total number of experimental units in the completely randomized design is twenty. The total degrees of freedom are calculated as the total number of units minus one, which yields nineteen, representing the complete set of independent comparisons possible in the experiment.

49. (C) 2.5
First, the treatment mean square is calculated by dividing the treatment sum of squares by its degrees of freedom, giving ten. Next, the error mean square is calculated by dividing the error sum of squares by its degrees of freedom, giving four. Finally, dividing ten by four yields two point five.

50. (D) II and IV
In a Randomized Block Design, blocks are oriented perpendicular to the fertility gradient to ensure homogeneity within each block. Additionally, the design requires each treatment to appear exactly the same number of times in every block, meaning varying replication numbers per block is incorrect, making statements two and four wrong.

51. (A) Maximize between-block and minimize within-block variance.
The primary purpose of blocking in a Randomized Block Design is to group homogeneous experimental units together to minimize the variation within each block. Simultaneously, this maximizes the variance between the blocks, which can then be partitioned out of the error sum of squares, enhancing experimental precision.

52. (B) $((t-1)(r-1))$
For a Randomized Block Design containing t treatments and r blocks or replications, the error degrees of freedom are calculated as the product of t minus one and r minus one. This represents the remaining independent pieces of information after accounting for treatment and block differences in the analysis.

53. (B) East to West
If the soil fertility gradient in an experimental field runs from North to South, the blocks should be oriented East to West. This perpendicular orientation ensures that the soil characteristics are as homogeneous as possible within each block, while the fertility variation is successfully captured between the blocks.

54. (C) The orthogonality of the design is lost.
When an individual plot value is missing in a Randomized Block Design, the balance of the experimental layout is disrupted. Consequently, the orthogonality of the design is lost, which means that treatment effects and block effects can no longer be estimated independently without performing specialized missing plot calculations.

55. (A) $\frac{rB+tT-G}{(r-1)(t-1)}$
The formula for estimating a single missing value in a Randomized Block Design incorporates the number of blocks, the sum of remaining observations in the block with the missing value, the number of treatments, the sum of remaining

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observations for that treatment, and the grand total of all observed values.

56. (B) Reduced by 1
After substituting an estimated missing value in a Randomized Block Design, the analysis of variance is performed on the reconstructed dataset. To correct for the fact that one data point was estimated rather than observed, the error degrees of freedom must be reduced by one before performing significance tests.

57. (B) Square root transformation
For count data exhibiting a Poisson distribution where the variance is proportional or equal to the mean, a square root transformation is the most appropriate technique. This transformation stabilizes the variance and helps the transformed observations approximate a normal distribution, satisfying the core assumptions of the analysis of variance.

58. (B) The standard deviation is proportional to the mean.
A logarithmic transformation is typically applied to experimental data when the standard deviation is proportional to the treatment mean, which often occurs with multiplicative effects. Taking logs converts multiplicative relationships into additive ones and successfully stabilizes the variance across different treatment groups, fulfilling ANOVA assumptions.

59. (A) Values range widely, extending outside 30% to 70%.
The arcsine or angular transformation is recommended for percentage or proportion data when the values cover a wide range, specifically extending outside the thirty to seventy percent interval. Percentages near the extremes of zero and one hundred have skewed binomial distributions, which this transformation successfully normalizes.

60. (A) I, II and V
Square root transformation works well for rare event counts, and logarithmic transformations require adding a constant like zero point five or one if zeros exist in the data. Because data transformations aim to stabilize variance without altering the core hypothesis, statements one, two, and five are correct.

61. (D) Evaluate interaction effects between multiple factors.
Factorial experiments are highly advantageous because they allow researchers to evaluate the interaction effects between multiple factors simultaneously. Rather than testing one factor at a time, this approach reveals whether the response to one factor depends on the levels of another, providing a comprehensive understanding of biological systems.

62. (B) 8
In a two cubed factorial experiment, there are three distinct factors, with each factor evaluated at exactly two levels. The total number of treatment combinations is calculated by multiplying the levels of all factors together, which mathematically equals two raised to the power of three, yielding eight combinations.

63. (B) $\big((a-1)(b-1)\big)$
The degrees of freedom for the interaction effect between factor A and factor B in a factorial experiment are calculated by multiplying the degrees of freedom of the individual factors. This calculation is represented as the quantity a minus one multiplied by the quantity b minus one.

64. (D) The simple effect of a factor averaged over all other factor levels.
In a factorial design, the main effect of a specific factor represents the average change in the response variable produced by varying the levels of that factor. This change is calculated by averaging the simple effects of the factor across all levels of the other factors in the experiment.

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65. (A) Reduce block size by sacrificing high-order interactions.
Confounding in factorial experiments is a specialized technique used to reduce the required block size when the total number of treatment combinations is large. By deliberately confounding high-order interactions of little biological interest with blocks, within-block homogeneity is preserved, improving the precision of main effects.

66. (C) Block effects
In a completely confounded two cubed factorial experiment replicated r times, the specific interaction selected for confounding is completely merged with the block effects. Because the

ANSWERS

1. (A) It takes only isolated, countable values.
A discrete variable in agricultural data is defined as a variable that can take only isolated, countable values, such as the number of plants or seeds. Unlike continuous variables that span a real range, these variables cannot have fractional values between the counted units, making them highly distinct.

2. (C) Quantitative variables represent measurable numerical properties.
Quantitative variables represent measurable numerical properties that can be ordered and compared mathematically, such as crop yields or heights. In contrast, qualitative variables describe non-numerical attributes or categories, like grain texture or flower color, which lack inherent magnitude and cannot be analyzed using standard arithmetic operations.

3. (A) I and II
Plant height can take any real value within a continuous range, making it a continuous variable. The number of tillers per plant represents distinct, countable counts, which makes it a discrete variable. Grain color is a qualitative attribute rather than a quantitative one, meaning only the first two statements are scientifically accurate.

4. (D) By averaging the lower and upper limits of a class.
The class mark represents the midpoint of a specific class interval within a frequency distribution. It is calculated by averaging the lower and upper limits of that class, summing them together and dividing by two. This value acts as a representative central estimate for all individual observations grouped in that interval.

5. (B) More than cumulative frequency
A more than cumulative frequency is calculated by summing the frequencies of classes starting from the highest class down to the lowest. This cumulative value represents the total number of observations that are greater than or equal to the lower boundary of each respective class, facilitating detailed distributional analysis.

6. (A) Both A and R are true and R is the correct explanation of A.
Highly skewed distributions contain extreme outliers that disproportionately pull the arithmetic mean toward the tail. Because the median is a positional measure representing the exact midpoint of sorted data, it remains unaffected by these extreme values. Consequently, the median provides a far more representative measure of central tendency in skewed datasets.

7. (D) Median
The median possesses a unique mathematical property where the sum of the absolute deviations of all observations from it is minimized. Any other value, including the arithmetic mean, will result in a larger sum of absolute deviations, making the median the optimal point for minimizing total absolute distance in a dataset.

8. (A) Zero
The sum of individual deviations from the arithmetic mean is always equal to zero because the mean acts as the balance point of the dataset. The total sum of the positive deviations for values above the mean perfectly cancels out the total sum of the negative deviations for values below it.

9. (A) P-2, Q-4, R-1, S-3
The arithmetic mean minimizes the sum of squared deviations, while the geometric mean is highly appropriate for averaging ratios and percentages. The harmonic mean provides the correct average for rates and speed variables, whereas the mode represents the most frequently occurring value in a dataset, linking each measure to its core properties.

10. (B) I and IV
The range is not based on all observations, as it only considers the difference between the maximum and minimum values. While standard deviation is independent of changes in the origin of scale, it is directly affected by changes in scale, meaning that both of these statements are incorrect.

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that blocking was highly effective at reducing experimental error in the study.

78. (C) The sum of relative yields of component crops to sole crops.
In intercropping experiments, the Land Equivalent Ratio is defined as the sum of the relative yields of the component crops compared to their respective sole crop yields. It quantifies the relative land area required under sole cropping to produce the same yields achieved under the intercropping system.

79. (B) Yield advantage of intercropping.
A Land Equivalent Ratio value greater than one point zero indicates a clear yield advantage of the intercropping system over sole cropping. It signifies that intercropping is more biologically efficient, meaning that sole cropping would require more total land area to produce the same combined yield of the component crops.

80. (B) I and III
The Area Time Equivalent Ratio accounts for the duration that component crops spend in the field, making it highly distinct from the Land Equivalent Ratio. It provides a more realistic comparison of productivity when the component crops differ significantly in their growing periods, meaning statements one and three are correct.

81. (A) Competitive relationship and dominance of crops.
In intercropping systems, the Aggressivity index is a valuable metric used to measure the competitive relationship between the component crops. It indicates how much the relative yield increase of one crop exceeds that of the other, identifying which crop acts as dominant and which behaves as subordinate in the mixture.

82. (C) Multi-environment trials.
Pooled analysis of variance is a statistical method conducted to analyze combined data obtained from multi-environment trials, such as experiments repeated across multiple locations or years. This analysis allows researchers to estimate the main treatment effects and evaluate the consistency of those treatments across different environmental conditions.

83. (A) Homogeneity of error variances.
Before performing a pooled analysis of variance across different locations or years, it is critical to test for the homogeneity of the individual error variances. If the error variances are heterogeneous, the combined analysis can be biased, meaning a transformation or alternative weighted analysis must be considered instead.

84. (D) Bartlett's test
Bartlett's test is a standard statistical test commonly employed to evaluate the homogeneity of variances across multiple independent groups prior to conducting a pooled analysis of variance. It tests the null hypothesis that all group variances are equal, which is a key requirement for pooled ANOVA validity.

85. (B) Genotypes respond differently to environments.
In multi-location trials, a statistically significant Genotype by Environment interaction indicates that the genotypes respond differently to different environmental conditions. This means that the relative performance and ranking of the genotypes are inconsistent across locations, requiring breeders to identify specifically adapted genotypes for particular target environments.

86. (C) Mean
The arithmetic mean cannot be determined graphically using an cumulative frequency curve, also known as an ogive. While positional measures like the median, quartiles, and deciles can be easily located by finding specific percentage points on the curve, the mean requires algebraic calculation involving all individual values.

87. (D) Symmetrical
A distribution in which the arithmetic mean, median, and mode are perfectly identical is a symmetrical distribution. In such cases, the data values are distributed evenly on both sides of the central peak, resulting in zero skewness, as typically observed in a perfect, bell-shaped normal curve.

88. (A) Mean > Median > Mode
In a positively skewed distribution, the long tail extends toward the higher values on the right. Because the mean is heavily pulled by these extreme positive values, while the mode remains at the highest peak, the resulting relationship among the measures of central tendency is mean greater than median greater than mode.

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89. (B) Median
The second quartile of a dataset corresponds exactly to the median. Both of these statistical

22. (C) Squared residuals
The line of best fit in simple linear regression is calculated using the method of ordinary least squares. This mathematical approach derives the optimal intercept and slope parameters by minimizing the sum of the squared residuals, which are the vertical distances between the observed values and the predicted regression line.

23. (D) Positive
The regression coefficient of Y on X and the regression coefficient of X on Y must share the exact same mathematical sign because both are mathematically linked to the covariance between the two variables. Since covariance determines the sign of both coefficients, if one is positive, the other must also be positive.

24. (A) Correlation coefficient
The geometric mean of the two regression coefficients, namely Y on X and X on Y, yields the correlation coefficient. This relationship is mathematically represented as the square root of the product of the two slope coefficients, preserving the algebraic sign of the slopes to indicate the direction of the relationship.

25. (A) III, I, II, IV
Testing the significance of a correlation coefficient begins by formulating the null hypothesis that the population correlation is zero. Next, the t -statistic is calculated, followed by determining the appropriate degrees of freedom based on sample size. Finally, the calculated t-statistic is compared with the critical t-value to make a decision.

26. (B) The proportion of total variation in Y explained by X.
The coefficient of determination represents the proportion of the total variation in the dependent variable that is explained or accounted for by the independent variable in the regression model. Calculated as the square of the correlation coefficient, it provides a direct measure of the model's goodness of fit.

27. (B) 0.64
The coefficient of determination is calculated by squaring the correlation coefficient. When the correlation coefficient is equal to zero point eight, squaring this value yields zero point six four. This indicates that sixty-four percent of the variation in the dependent variable is explained by the variation in the independent variable.

28. (C) F-test or t-test
To assess whether the regression coefficient in a simple linear regression model is significantly different from zero, either an F-test or a t -test is utilized. Both tests are mathematically equivalent in the simple linear case, evaluating whether the independent variable accounts for a significant proportion of the variance in the dependent variable.

29. (D) Rejects a true null hypothesis.
A Type I error is committed when a researcher incorrectly rejects a null hypothesis that is actually true in the population. Often referred to as a false positive, the probability of committing this error is denoted by alpha, which corresponds to the chosen level of significance for the statistical test.

30. (C) A is true but R is false.
The level of significance represents the maximum allowable probability of committing a Type I error. However, decreasing this level actually increases the probability of committing a Type II error, as the two error rates are inversely related when sample size is held constant, making the reasoning statement false.

31. (B) One minus probability of Type II error.
The power of a statistical test is defined as the probability of correctly rejecting a false null hypothesis, which represents a true positive result. Mathematically, it is calculated as one minus the probability of committing a Type II error, reflecting the test's ability to detect an actual effect or difference.

32. (B) $n-1$
In a simple one-sample t-test, the degrees of freedom are calculated as the sample size minus one. This reduction occurs because one degree of freedom is lost when estimating the sample mean, which is used as a constraint to calculate the sample standard deviation and the test statistic.

33. (A) When observations in both groups are paired or correlated.
A paired t-test is preferred over an independent two-sample t-test when the observations in the two groups are naturally paired or correlated, such as pre-treatment and post-treatment

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its significance helps determine whether the independent variable contributes significantly to predicting the dependent variable, indicating whether the slope of the regression line is statistically different from zero.

102. (C) Student's t-distribution.
When testing the null hypothesis that the population correlation coefficient is equal to zero, the sampling distribution of the test statistic follows Student's t-distribution with n minus two degrees of freedom. This t-test evaluates whether the observed sample correlation is strong enough to be considered statistically significant.

103. (B) 0.0
If two variables X and Y are completely independent, there is no linear association or relationship between them. Consequently, the expected correlation coefficient between these variables is exactly zero point zero, indicating that changes in one variable do not correspond to any predictable or systematic changes in the other.

104. (A) Assigning average ranks to tied values.
Spearman's rank correlation handles tied observations by assigning the average of the ranks that they would have otherwise occupied to each of the tied values. This adjustment ensures that the sum of the ranks remains constant and prevents bias in the calculation of the rank correlation coefficient.

105. (A) II, III, IV, I
Conducting an Analysis of Variance begins by computing the correction factor. Next, the total sum of squares is calculated, followed by determining the treatment sum of squares. Finally, the error sum of squares is computed by subtracting the treatment sum of squares from the total sum of squares.

106. (B) Degrees of freedom
In an analysis of variance table, the mean square for any source of variation is calculated by dividing its sum of squares by the corresponding degrees of freedom. This ratio provides an unbiased estimate of the variance components, which is essential for conducting F-tests to evaluate the statistical significance of experimental treatments.

107. (A) All population means are equal.
In a one-way analysis of variance, the null hypothesis posits that there are no systematic differences among the treatment groups. This is mathematically expressed by stating that all the respective population means are equal. If this hypothesis is rejected, it indicates that at least one of the population means differs from the others.

108. (C) One-tailed test
A directional alternative hypothesis specifies that a parameter is either strictly greater than or less than a hypothesized value. Testing such a directional claim requires a one-tailed statistical test. This approach allocates all critical significance area to a single tail of the probability distribution, which enhances statistical power for detecting differences in that specific direction.

109. (D) Harder to reject the null hypothesis.
Reducing the significance level decreases the probability of committing a Type I error by narrowing the rejection region. Consequently, the sample evidence must be stronger to reach the critical threshold. This adjustment increases the conservative nature of the statistical test, thereby making it more difficult to reject the null hypothesis during data analysis.

110. (C) A is true but R is false.
A probability value below the designated significance level indicates that the observed sample data are highly improbable under the assumption of the null hypothesis, justifying its rejection. However, this value does not represent the probability that the null hypothesis itself is true, but rather the probability of obtaining such extreme results given that hypothesis.

111. (B) Normally distributed
The paired t-test is a parametric statistical method used to compare two related sample means. It requires the underlying assumption that the differences between the paired observations are normally distributed. This normality condition ensures the validity of the calculated test statistic and the accuracy of the resulting significance levels during hypothesis evaluation.

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174. (C) Reduces block size to maintain unit homogeneity.
When a factorial experiment contains numerous treatment combinations, the required block size increases, which often introduces substantial environmental heterogeneity within blocks. Confounding solves this issue by partitioning the treatment combinations into smaller, incomplete blocks. This reduction in block size preserves local control and minimizes the experimental error variance.

175. (B) Fewer degrees of freedom than the sub-plot error (Error b).
In a split-plot design, the main-plot treatments are arranged in a randomized block structure, which results in fewer experimental units for the main factor. Because the main plots are larger and fewer, the degrees of freedom associated with error a are substantially smaller than those associated with the sub-plot error b.

176. (D) Main plot
Split-plot designs are utilized when different experimental factors require different plot sizes for practical management. Factors that are difficult to apply on small areas, such as irrigation or primary tillage, are assigned to the larger main plots. Sub-plot treatments, which are easier to manage, are then randomized within these main plots.

177. (A) Interaction effect between the two factors.
A strip-plot design is structured by applying two factors in perpendicular strips across a replication block, resulting in three separate error terms. This layout provides lower precision for the main effects of both factors. However, because of the systematic crossing of the strips, it provides the highest precision for estimating their interaction.

178. (C) Error variance
The precision of an experimental design refers to its capacity to detect true treatment differences. Mathematically, precision is inversely proportional to the experimental error variance. A smaller error variance narrows the standard error of treatment differences, which increases the sensitivity of the F-test and enhances the statistical power.

179. (A) Area Time Equivalent Ratio
In multi-species cropping systems, the duration of land occupancy by each crop is a critical factor in overall productivity. The Area Time Equivalent Ratio is an index developed to incorporate both land area and the duration of the crop growth cycle, providing a more realistic assessment of intercropping efficiency over time.

180. (D) Crop A is more competitive than crop B.
The competitive ratio measures the relative aggressiveness and resource-use capability of crops grown in an intercropping mixture. A competitive ratio greater than one point zero for crop A relative to crop B indicates that crop A is the dominant competitor, utilizing shared field resources more efficiently than crop B.

181. (B) It is highly sensitive to departures from normality.
Bartlett's test is a standard procedure used to evaluate the homogeneity of variances across multiple populations. However, this test is highly sensitive to any departures from the assumption of normality. If the underlying data are non-normal, the test may yield a significant result even when the variances are actually homogeneous.

182. (C) Distinct attributes or labels.
Variables are classified based on their measurement characteristics. A qualitative variable, also known as a categorical variable, describes non-numerical properties of a population. Instead of representing quantities or measurements, it classifies observations into distinct groups or categories based on specific attributes, labels, or qualities, such as variety or color.

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183. (D) Loss of original data identity and precision.
Grouping raw quantitative data into class intervals is a common technique for simplifying large datasets. However, this process replaces individual observations with class frequencies. Because the exact values of the observations are no longer identifiable, grouping inevitably results in a loss of original data identity and statistical precision during analysis.

184. (A) Class width or magnitude
In frequency distributions, class intervals are defined by upper and lower boundaries. The difference between these two limits represents the

122. (B) Blocks
The efficiency of a randomized block design is measured by its capacity to isolate environmental variation. A large mean square for blocks indicates that a substantial portion of the total variation is successfully accounted for by the blocking factor. This separation prevents this variation from inflating the experimental error mean square, thereby enhancing design precision.

123. (A) Randomization
Fisher's three basic principles of experimental design include replication, randomization, and local control. Randomization requires that every treatment has an equal chance of being assigned to any experimental unit within a block. Allocating treatments sequentially in a fixed order violates this principle, introducing systematic bias and invalidating the assumption of independent error terms.

124. (C) Independent values in a sample free to estimate a parameter.
The mathematical concept of degrees of freedom represents the number of independent observations that are free to vary in a dataset. When sample statistics are calculated, certain constraints or parameter estimations are imposed on the data. The degrees of freedom are equal to the total observations minus the number of such constraints applied.

125. (D) Zero values
Logarithmic transformations are utilized to stabilize variance and achieve normality when the variance is proportional to the mean. However, the logarithm of zero is mathematically undefined. Adding a constant of one to each observation solves this issue, making the transformation suitable for datasets containing zero counts, such as insect populations or weed densities.

126. (C) Wilcoxon signed-rank test
The Wilcoxon signed-rank test serves as the non-parametric equivalent to the parametric paired t-test. It is used when the differences between paired observations do not satisfy the assumption of normality. Instead of analyzing raw values, this test evaluates the ranks and signs of the differences, providing a robust comparison of two related samples.

127. (B) Arcsine
In biological experiments, data expressed as percentages or proportions derived from binomial distributions often violate the assumption of constant variance. When these proportions lie near zero or one, their variance is highly dependent on the mean. The arcsine or angular transformation stabilizes this variance, preparing the data for standard analysis of variance.

128. (D) Factorial experiment
Evaluating multiple factors simultaneously in all possible combinations allows researchers to assess both individual and joint effects. Such an investigation is known as a factorial experiment. In this case, examining three levels of nitrogen and four levels of phosphorus results in twelve distinct treatment combinations, which enables the assessment of interaction effects.

129. (A) Simple effects of one factor across levels of the other.
A statistically significant interaction indicates that the influence of one experimental factor depends on the specific level of another factor. In this scenario, interpreting overall main effects can be misleading. Researchers should focus on the simple effects, which evaluate the differences among levels of one factor within each individual level of the other factor.

130. (C) All factors have the same number of levels.
Symmetrical factorial designs are experimental layouts where every investigated factor has the same number of levels, represented as s to the power of k. This symmetry simplifies both the field arrangement and the mathematical analysis, ensuring that the main effects and their corresponding interactions are estimated with uniform precision across the entire experiment.

131. (A) High and low (e.g., 0 and 1)
In a two-level factorial experiment, each factor is evaluated at exactly two distinct levels, which represent opposing experimental conditions. These levels are conventionally designated as high and low, or mathematically symbolized as one and zero. This standardized notation simplifies the formulation of treatment combinations and the algebraic calculation of main effects and interactions.

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112. (D) Approximates the standard normal distribution.
As the sample size increases, the degrees of freedom for the t-distribution grow proportionally. This change alters the shape of the curve, reducing the probability in the tails and increasing the peak. Consequently, the t-distribution converges toward and eventually approximates the standard normal distribution, as dictated by asymptotic statistical theory.

113. (A) Numerator and denominator mean squares.
The F-distribution is defined by two distinct degrees of freedom. These values are determined by the independent components of variance used in the ratio. Specifically, the critical value depends on the degrees of freedom associated with the numerator mean square and those associated with the denominator mean square in the variance analysis.

114. (C) Chi-square test
Evaluating the conformity of observed phenotypic ratios to a theoretical genetic ratio involves testing categorical frequency distributions. The classical chi-square goodness of fit test is designed for this purpose, as it measures the magnitude of deviations between observed and expected frequencies. This test determines whether these differences are purely due to random chance.

115. (A) P-2, Q-4, R-1, S-3
Statistical concepts possess distinct operational definitions. The null hypothesis assumes no difference between populations. A Type II error occurs when a false null hypothesis is not rejected. The level of significance represents the probability of rejecting a true null hypothesis. The power of a test measures the probability of successfully rejecting a false null hypothesis.

116. (A) 0.5
Yates' correction for continuity is applied to two-by-two contingency tables with small expected cell frequencies. It adjusts for the error introduced by approximating a discrete binomial distribution with a continuous chi-square distribution. The correction reduces the absolute difference between observed and expected frequencies by exactly point five before squaring and dividing.

117. (B) Variations among experimental units within the same treatment.
In a completely randomized design, treatments are allocated entirely at random to homogeneous experimental units. Because there are no blocking factors to partition environmental heterogeneity, any observed variation among experimental units that receive the identical treatment is attributed to random chance. This variation constitutes the experimental error in the analysis of variance.

118. (C) Completely Randomized Design
The completely randomized design does not partition the total variation into blocking sources. Because no degrees of freedom are lost to blocks, rows, or columns, the remaining degrees of freedom assigned to the experimental error are maximized. This characteristic makes this design highly efficient when the experimental material is completely uniform.

119. (D) It is highly inefficient for heterogeneous areas lacking local control.
A completely randomized design assumes that all experimental units are highly uniform. When applied to heterogeneous areas, such as fields with fertility gradients, the design cannot isolate this systematic variation. Consequently, this uncontrolled variation enters the experimental error term, inflating its value and severely reducing the precision and efficiency of the entire experiment.

120. (B) II, III and IV
Missing plot techniques estimate missing values to minimize the error sum of squares, which restores the orthogonal structure of the experimental data. However, because the missing value is estimated rather than observed, the degrees of freedom for the experimental error must be reduced by one for each estimated value to ensure unbiased variance testing.

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121. (B) Perpendicular to the slope.
When establishing a randomized block design, blocking must minimize variation within each block while maximizing variation between blocks. To achieve this in the presence of a unidirectional fertility gradient, blocks should be oriented perpendicular to the slope. This alignment ensures that the experimental units within each block experience relatively uniform soil productivity conditions.

142. (C) Error variances are heterogeneous across environments.
Bartlett's test is a statistical procedure used to evaluate the homogeneity of variances across multiple groups or environments. A significant probability value less than point zero five indicates that the null hypothesis of equal variances is rejected. This confirms that the error variances are heterogeneous, which complicates the direct pooling of environmental data.

143. (B) Performing data transformation or using weighted ANOVA.
When error variances are heterogeneous in multi-environment trials, a standard analysis of variance is invalid because it assumes homogeneous errors. To address this violation, researchers can perform stabilizing data transformations or employ a weighted analysis of variance. These adjustments weight the data by the inverse of local variances to ensure unbiased pooled testing.

144. (D) $(r-1)(m-1)$
In a pooled analysis of variance conducted across multiple locations, the interaction between genotypes and environments must be evaluated. The degrees of freedom for this interaction are calculated as the product of the number of locations minus one and the number of genotypes minus one, representing the independent combinations of these factors.

145. (A) Assumes any numerical value within an interval.
A continuous variable is a type of quantitative variable that can take on an infinite number of values within a specified range or interval. Unlike discrete variables, which only assume distinct integers, continuous variables are measured on scales that allow for fractional values, such as height, crop yield, weight, or temperature.

146. (C) Histogram
A histogram is a specialized graphical representation designed to display continuous frequency distributions. It consists of adjacent rectangles erected over class intervals, where the area of each bar is proportional to the frequency of observations in that class. This contiguous structure visually highlights the density and shape of continuous data.

147. (A) Ogive
A cumulative frequency curve, commonly referred to as an ogive, is a graphical representation of the cumulative totals of a frequency distribution. It is constructed by plotting cumulative frequencies against class boundaries. Ogives are useful for interpolating values, such as determining medians, quartiles, or percentiles directly from the plotted distribution.

148. (B) 20
The arithmetic mean is the sum of all observations divided by their total count. If a dataset of ten observations has a mean of twenty, its total sum is two hundred. Removing an observation that is exactly equal to the mean leaves a sum of one hundred eighty, which, divided by nine, yields twenty.

149. (B) Rates, prices, and speeds
The harmonic mean is a specialized measure of central tendency calculated as the reciprocal of the arithmetic mean of the reciprocals of the data. It is particularly appropriate for averaging ratios, speeds, prices, and time rates, where the variable is expressed in relation to a fixed unit of another scale.

150. (A) Both A and R are true and R is the correct explanation of A.
In statistical analysis, the variance is preferred over the range as a measure of dispersion. The range is highly unstable because it is calculated using only the two extreme values, ignoring the rest of the dataset. Conversely, the variance incorporates every single observation, making it a highly reliable and mathematically stable metric.

151. (D) Harmonic Mean
The calculation of the harmonic mean requires taking the reciprocal of each observation in the dataset. If any value within the dataset is equal to zero, its reciprocal is mathematically undefined. Consequently, the harmonic mean cannot be calculated or defined for any sample that contains a zero value among its observations.

152. (A) Variance divided by sample size.
The standard error of the mean measures the dispersion of sample means around the true population mean. It is calculated by dividing the standard deviation by the square root of the sample size. Consequently, squaring this

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132. (D) Confounding
Confounding is an experimental technique used in factorial designs to reduce block size when the number of treatment combinations is large. By deliberately blending a specific treatment effect with block differences, researchers can maintain small, homogeneous blocks. This process sacrifices information on the confounded effect to improve the precision of more critical comparisons.

133. (B) Highest-order interaction
In multi-factor experiments, high-order interactions involving three or more factors are difficult to interpret biologically. Because these interactions are of minor practical interest, they are preferentially confounded with block effects. This strategic choice keeps the blocks small and uniform, while preserving the full precision required to estimate main effects and simple first-order interactions.

134. (C) All the replications.
Confounding can be applied either partially or completely across an experimental design. In complete confounding, the exact same interaction effect is confounded with blocks across all the replications in the study. Consequently, no information about this specific interaction can be recovered from any portion of the experiment during the subsequent analysis of variance.

135. (D) $(r-1)(m-1)$
In a split-plot design, the total variation is partitioned into main-plot and sub-plot sections. The error term for the main plots, designated as error a, is used to test the main-plot treatments. Its degrees of freedom are calculated as the product of the replication minus one and the main-plot factor levels minus one.

136. (A) Lower than sub-plot treatments.
In split-plot designs, main-plot treatments are assigned to larger, primary experimental units, whereas sub-plot treatments are randomized within those main plots. Because the main plots are larger and subject to greater soil heterogeneity, the main-plot error is typically larger than the sub-plot error. Consequently, the comparison precision for main-plot treatments is lower.

137. (B) Strip-plot Design
A strip-plot design, also known as a split-block design, involves laying out two factors in perpendicular strips across the replication blocks. This arrangement introduces two-way randomization, as both horizontal and vertical factors are randomized in continuous strips. This design is highly convenient for field operations requiring long, uninterrupted passes of agricultural machinery.

138. (B) Factors requiring large plots like tillage and irrigation.
Strip-plot designs are uniquely suited for agricultural experiments where multiple factors require large, continuous land areas for practical execution. For example, tillage implements and irrigation systems cannot be easily randomized on small, isolated plots. Applying these treatments in perpendicular strips accommodates mechanical field operations while maintaining a statistically sound experimental structure.

139. (A) The test design is more precise than the base design.
Relative efficiency is a statistic used to compare the precision of two experimental designs. If the calculated relative efficiency value is greater than one, it demonstrates that the test design is more precise than the base design. This means the test design achieves a smaller error variance for the same experimental resources.

140. (C) Respective sole crop yields evaluated under identical management.
The Land Equivalent Ratio is a widely used index for evaluating the productivity of intercropping systems. It is calculated by summing the ratios of intercrop yields to their respective sole crop yields, both grown under identical management practices. A ratio greater than one indicates that intercropping is more biologically productive than monoculture.

141. (D) Ratio of LER of the two crops, adjusted for sown proportions.
The competitive ratio is an index used in intercropping research to assess the relative competitiveness of component crops. It is mathematically calculated as the ratio of the individual land equivalent ratios of the two crops, adjusted by their respective initial sown proportions. This index identifies which crop is dominant and which is subordinate.

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164. (D) Local control
Fisher's three principles of experimental design serve distinct purposes. While replication estimates error and randomization ensures independence, local control is designed to reduce experimental error by grouping homogeneous units into blocks. This grouping isolates known sources of environmental variation, such as fertility gradients, from the random error term in analysis.

165. (B) Maximum error degrees of freedom.
The completely randomized design is the simplest experimental layout, where treatments are assigned to plots without restriction. Because no degrees of freedom are lost to blocking or spatial grouping, this design reserves the maximum possible degrees of freedom for the experimental error term. This characteristic maximizes the sensitivity of the statistical analysis.

166. (C) Intra-block variance is minimized and inter-block variance is maximized.
The effectiveness of blocking in a randomized block design depends on grouping experimental units so that conditions are uniform within each block. Consequently, the variation within blocks is minimized, while the variation between blocks is maximized. This separation isolates environmental differences, preventing them from inflating the calculated experimental error variance.

167. (D) Minimizes the error sum of squares.
Missing plot techniques estimate missing observations to restore the balanced structure of the dataset. The mathematical objective of this estimation is to minimize the error sum of squares in the analysis of variance. This minimization ensures that the subsequent tests of treatment effects remain as unbiased and precise as possible.

168. (A) Iterative calculation steps until estimates converge.
When multiple observations are missing in a randomized block design, a simple single-value formula cannot be applied directly because the missing values are mutually dependent. Instead, researchers use an iterative process, alternately estimating each missing value using the standard formula until the calculated estimates stabilize and converge to a final solution.

169. (B) Proportional to the mean.
Parametric analyses of variance require that the treatment variances are independent of their means. When data follow a Poisson distribution, such as insect counts, the variance is proportional to the mean. Applying a square root transformation stabilizes this variance, making the data suitable for standard statistical testing methods.

170. (B) Base 10 or natural log.
Logarithmic transformations are utilized in agricultural research when the standard deviation of treatment samples is proportional to their mean. In these cases, converting the raw observations using base ten or natural logarithms stabilizes the variance. This mathematical adjustment normalizes the distribution, satisfying the assumptions of parametric analysis of variance.

171. (A) Evaluate interaction effects between factors.
Factorial experiments allow researchers to study two or more factors simultaneously. The primary advantage of this approach over separate single-factor experiments is the ability to detect and evaluate interaction effects. This reveals whether the influence of one factor is altered by the different levels of another factor in the study.

172. (C) Treatment combinations sum of squares.
In a two-factor factorial experiment, the total treatment variation is represented by the treatment combinations sum of squares. To isolate the interaction sum of squares, the individual main effects of factor A and factor B must be subtracted from this treatment combinations sum of squares during the analysis of variance.

173. (D) Exponential growth in treatment combinations.
As the number of factors or their respective levels increases in a full factorial design, the total number of treatment combinations grows exponentially. This rapid expansion requires a massive increase in experimental units, land area, and resources. Consequently, the trial becomes highly difficult to manage and coordinate in field conditions.

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suggesting that the treatments have a significant effect.

196. (D) $\frac{\text{Row Total} \times \text{Column Total}}{\text{Grand Total}}$
In a chi-square test of independence using a contingency table, expected frequencies are calculated under the null hypothesis of no association. For any individual cell, the expected frequency is determined by multiplying its corresponding row total by its column total, and then dividing that product by the grand total.

197. (B) Provide an estimate of experimental error.
Replication, one of Fisher's three fundamental principles of experimental design, involves applying the same treatment to multiple independent experimental units. The primary statistical purpose of replication is to provide an estimate of experimental error. This estimate is essential for conducting significance tests and determining the precision of treatment comparisons.

198. (C) Treatments and Error
The completely randomized design is the simplest experimental structure, applied when experimental units are highly uniform. Because there are no blocking factors to control spatial heterogeneity, the analysis of variance partitions the total variation into only two distinct sources. These sources are the variation due to treatments and the residual experimental error.

199. (D) All treatments applied exactly once.
A randomized block design relies on grouping experimental units into blocks to control spatial variation. To maintain design balance and orthogonality, every block must serve as a single complete replication. This requirement means that all of the experimental treatments must be applied within each block exactly once in a randomized layout.

200. (A) Correcting the treatment sum of squares.
When a missing value in a randomized block design is estimated, the resulting data structure is no longer perfectly orthogonal. This imbalance introduces a slight upward bias in the treatment sum of squares. To maintain unbiased F-tests, researchers must apply a mathematical correction to adjust the treatment sum of squares downward.

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201. (B) Arcsine
Data expressed as proportions or percentages often exhibit a binomial distribution where the variance is dependent on the mean, violating the homoscedasticity assumption of ANOVA. The arcsine transformation, which calculates the inverse sine of the square root of each proportion, stabilizes the variance across the entire zero to one scale.

202. (B) 6
In a factorial design, the total number of unique treatment combinations is determined by multiplying the number of levels of each individual factor. For an experiment exploring three levels of Nitrogen and two levels of Phosphorus, the calculation is three multiplied by two, resulting in exactly six unique treatment combinations.

203. (A) Block effects
Confounding is an advanced experimental technique used in factorial designs to keep block sizes small and homogeneous. The defining characteristic of this approach is the deliberate assignment of specific treatment interactions to block differences. Consequently, these treatment effects are completely mixed with block effects, sacrificing them to improve overall precision.

204. (C) Independently within each main plot area.
In a split-plot design, the randomization of treatments occurs in two distinct stages. First, the main-plot factor is randomized across the principal plots. Second, the sub-plot treatments, such as fertilizer levels, are randomized independently within each of those main-plot areas. This restricted randomization establishes the hierarchical structure of the design.

205. (D) Lower precision for both main effects.
In a strip-plot design, factors are arranged in perpendicular strips, which simplifies field operations. However, this layout partitions the experimental error into three separate error terms. While this structure improves the precision of the interaction effect, it results in lower precision for estimating the main effects of both factors compared to split-plot designs.

206. (C) Inverse error variances of the two designs.
Relative efficiency compares the precision of two experimental designs tested on the same material. Since precision is mathematically

range of values covered by a single class, which is termed the class width or magnitude. This width is typically kept uniform across classes to ensure consistent density representation.

185. (B) Negative
Skewness describes the asymmetry of a probability distribution around its mean. If the distribution has a long, extended tail stretching toward the left side, it is negatively skewed. In this case, the mean is typically less than the median, reflecting the pull of the extreme low values in the tail.

186. (B) It shares the original units of measurement.
Variance measures dispersion in squared units, which makes it difficult to interpret in relation to the original data. Standard deviation is the square root of the variance, which restores the metric to the original scale. Consequently, standard deviation is preferred for descriptive statistics because it shares the same units.

187. (A) $\left(\frac{\sigma}{\mu}\right) \times 100$
The coefficient of variation is a dimensionless index used to compare the relative variability of datasets with different units or means. It is calculated by dividing the standard deviation by the arithmetic mean and multiplying the resulting ratio by one hundred to express the value as a percentage of the mean.

188. (C) A random cloud of points.
A scatter plot is a graphical tool used to visualize the relationship between two continuous variables. If there is no linear or non-linear correlation between the variables, the plotted coordinates will be distributed haphazardly across the graph. This lack of association displays as a random cloud of points without any trend.

189. (D) Both origin and scale.
The Pearson product-moment correlation coefficient is a standardized measure of linear association. A key mathematical property of this coefficient is its complete independence from changes in both origin and scale. This means adding a constant to or multiplying the variables by a constant does not alter the calculated correlation value.

190. (C) Lies precisely on the fitted regression line.
In simple linear regression, the least-squares estimation method minimizes the sum of squared residuals. A mathematical consequence of this minimization is that the fitted regression line must pass through the centroid of the data. Therefore, the point defined by the sample means of both variables lies precisely on the regression line.

191. (B) 1
In regression analysis of variance, the F-ratio compares the mean square due to regression against the residual mean square. If the true population coefficient of determination is zero, there is no linear relationship. Under this null hypothesis, both mean squares estimate the same error variance, yielding an expected F-ratio of approximately one.

192. (D) Type I error
A Type I error involves rejecting a true null hypothesis. If the null hypothesis states that an agrochemical is unsafe, a Type I error means concluding the chemical is safe when it is actually toxic. This mistake poses a severe hazard to public health and the environment, making it the more serious error.

193. (A) Acceptance region from the rejection region.
In hypothesis testing, the probability distribution of a test statistic is divided into two distinct areas based on the significance level. The critical value represents the exact boundary that separates the acceptance region from the rejection region. This value determines whether the calculated statistic is extreme enough to reject the null hypothesis.

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194. (C) Observations between groups are independent.
Applying an independent two-sample t-test requires that the data satisfy several assumptions. Crucially, the observations in one sample must have no relationship with or influence on the observations in the second sample. This independence of groups ensures that the calculated standard error and resulting probability levels are mathematically valid.

195. (A) Larger than the variation within treatments.
The F-ratio in an analysis of variance is calculated by dividing the treatment mean square by the error mean square. A large F-ratio indicates that the variation observed among the treatment means is substantially larger than the random variation within the treatment groups,

standard error yields the variance of the sample divided by the sample size.

153. (B) All observations in the sample are identical.
The coefficient of variation is calculated as the ratio of the standard deviation to the mean, expressed as a percentage. A coefficient of variation of zero percent indicates that the standard deviation is zero. This situation only occurs when there is no variation in the dataset, meaning all observations are identical.

154. (B) -1.0
The correlation coefficient measures the strength and direction of the linear relationship between two variables. If two variables consistently move in opposite directions at a constant rate, they exhibit a perfect negative linear association. This relationship is mathematically represented by a correlation coefficient of exactly negative one point zero under all conditions.

155. (A) P-2, Q-3, R-4, S-1
Regression models comprise specific elements. The independent variable is the predictor manipulated by the researcher. The dependent variable is the response being predicted. The intercept represents the value of the dependent variable when the independent variable is zero. The residual is the difference between the observed and predicted values in the model.

156. (C) Parallel to the X-axis
In the simple linear regression equation, the coefficient represents the slope of the line. If the slope coefficient is equal to zero, changes in the independent variable have no effect on the predicted value of the dependent variable. Consequently, the fitted regression line is completely horizontal and runs parallel to the horizontal axis.

157. (D) The model explains 95% of the variation in the dependent variable.
The coefficient of determination represents the proportion of total variation in the dependent variable that is explained by the regression model. A high coefficient of determination of point nine five indicates that ninety-five percent of this variability is accounted for by the independent variables, signifying a highly robust fit.

158. (B) $n-1$
In statistical analysis, calculating the total sum of squares involves measuring the deviations of individual observations from their overall sample mean. This estimation of the sample mean imposes a single constraint on the dataset. Therefore, the degrees of freedom for the total sum of squares are equal to the sample size minus one.

159. (B) Increasing the sample size.
Statistical power is the probability of correctly rejecting a false null hypothesis. It is influenced by the significance level, effect size, sample size, and data variability. Increasing the sample size reduces the standard error of the estimate, which narrows confidence intervals and mathematically maximizes the power of the statistical test.

160. (D) One-sample t-test
When evaluating whether a single sample mean differs from a specified population mean, the choice of test depends on the sample size and variance. If the population variance is unknown and the sample size is small, the standard normal z-test is inappropriate. Instead, the one-sample t-test is the mathematically correct procedure.

161. (A) Normal distributions and equal variances.
The independent two-sample t-test is a parametric procedure used to compare two separate group means. This test relies on several key assumptions, including the independence of observations, the normal distribution of the underlying populations, and the equality of variances between the two groups, which is also known as homoscedasticity.

162. (C) Means
Although analysis of variance decomposes the total variation into distinct variance components to construct an F-ratio, its fundamental statistical purpose is to test the null hypothesis that multiple population means are equal. It determines whether the variation among group means is significantly larger than the variation within the groups.

163. (A) The total observed frequencies.
In a chi-square goodness of fit test, the total number of observations must remain constant during the distribution analysis. Although the frequencies are distributed across different categories according to a theoretical ratio, the sum of these expected frequencies must mathematically equal the total of the observed frequencies in the sample.

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defined as the reciprocal of the error variance, relative efficiency is calculated as the ratio of the inverse error variances of the two designs, adjusted for their respective error degrees of freedom.

207. (B) 20%
A Land Equivalent Ratio of one point two five indicates that intercropping yields twenty-five percent more than sole cropping. To achieve the same yield with sole crops, twenty-five percent more land is required. Consequently, the actual land area saved by choosing the intercropping system instead of monoculture is exactly twenty percent.

208. (D) Homogeneous error variances.
Before conducting a pooled analysis of variance across multiple environments, researchers must verify that the data satisfy the assumptions of parametric analysis. Most importantly, the error variances across all environments must be homogeneous. This condition is formally evaluated using tests like Bartlett's test to ensure the validity of pooled F-tests.

209. (A) Perform a weighted ANOVA using error variances.
When Bartlett's test confirms that error variances are heterogeneous across experimental locations, a standard pooled analysis of variance is invalid. The most statistically sound remedy is to perform a weighted analysis of variance. In this approach, observations from each location are weighted by the reciprocal of their respective local error variances.

210. (C) Relative Yield
In intercropping research, the relative yield index represents the productivity of a component crop grown in a mixture. It is calculated by dividing the yield of the intercrop by the yield of that same crop grown as a sole crop under identical management. This ratio measures the individual contribution to land-use efficiency.

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(D) Proliferation of woody shrubs and unpalatable forbs

2011

35. Lignin decomposition in agricultural residues is primarily driven by which microbial group?
(A) White-rot fungi
(B) Anaerobic bacteria
(C) Nitrifying bacteria
(D) Actinomycetes

2013

36. Which process fundamentally differentiates biochar production from conventional aerobic composting?
(A) Extreme hyper-thermophilic bacterial action
(B) The addition of earthworms to the feedstock
(C) Pyrolysis under low or zero oxygen conditions
(D) Complete oxidation of carbon to carbon dioxide

2018

37. Which statement accurately identifies a major biochemical class of allelochemicals?
(A) Phenolic acids
(B) Polysaccharides
(C) Phospholipids
(D) Nucleotide bases

2002

38. The use of an Internet of Things (IoT) architecture in automated irrigation primarily relies on what integration?
(A) Advanced macro-level satellite weather forecasts completely replacing all actual field-level sensor data
(B) Direct manual measurement of local soil moisture status inputted periodically into a local spreadsheet
(C) Multi-rotor automated drones physically transporting irrigation water directly to moisture-stressed plants
(D) Sensor data transmitted to decision-support algorithms

2007

39. In assessing biomass energy, which parameter heavily dictates the combustion efficiency of agro-industrial residues?
(A) Moisture content and ash composition
(B) Soluble protein and amino acid fractions
(C) Endogenous presence of secondary allelochemicals
(D) Total chlorophyll and accessory pigment content

2022

40. Select the correct order of phases in traditional Shifting Cultivation.
(A) Slashing, Cropping, Burning, Fallow
(B) Slashing, Burning, Cropping, Fallow
(C) Burning, Slashing, Fallow, Cropping
(D) Fallow, Cropping, Slashing, Burning

2017

41. Which parameter directly evaluates the economic dimension of agricultural sustainability?
(A) Long-term soil biological activity and microbial respiration rates
(B) Total direct fossil fuel energy footprint of field machinery
(C) Distribution of gender equity and labor in farming communities
(D) Net economic returns and benefit-cost ratios

2025

42. In conventional tillage systems, the disruption of soil macroaggregates primarily leads to:
(A) Rapid mineralization of protected organic carbon pools
(B) Accelerated protection of intra-aggregate organic carbon
(C) Enhanced long-term soil organic carbon sequestration
(D) Increased physical stability of mycorrhizal fungal hyphal networks

2007

43. Which mechanism defines soil carbon sequestration?
(A) The rapid high-temperature burning of crop residues to form highly inert mineral ash
(B) Net transfer of CO_2 into long-lived soil organic pools
(C) The rapid physical conversion of organic soil horizons into waterlogged peat bogs artificially
(D) Downward lateral leaching of highly dissolved organic carbon into deep groundwater aquifers

2003

44. How does stratification of soil nutrients in zero-tillage systems affect crop roots?
(A) It completely prevents young crop roots from accessing deep subsoil water storage
(B) It promotes fine root proliferation near the soil surface
(C) It causes immediate severe biochemical toxicity to the radicle upon initial emergence
(D) It restricts all lateral and vertical root growth strictly to the deeper subsoil profile

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(A) High operational speed requirements causing extreme soil compaction
(B) Inability of the machine to sow wheat directly in standing paddy stubbles
(C) Strict requirement of specialized genetically modified crop seed varieties
(D) High initial machinery cost and limited custom hiring access

2017

10. Consider the following statements regarding the Land Capability Classification (LCC) system:
I. Classes I to IV are suitable for cultivation.
II. Class VIII land is highly suitable for intensive agriculture.
III. Limitations increase progressively from Class I to Class VIII.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I

2018

11. In wasteland mapping, which driver is most responsible for the creation of gullied or ravinous lands?
(A) Excessive and unchecked wind erosion occurring within extremely arid climates
(B) Unscientific water management and intense surface runoff
(C) Coastal salinity intrusion in low-lying deltaic ecosystems
(D) Accelerated high-altitude glacial retreat due to thermal warming

2010

12. Which ecological phase follows the slashing and burning step in traditional Shifting Cultivation (Jhum)?
(A) Climax forest development and restoration phase
(B) Cropping phase utilizing soil fertility
(C) Natural fallow secondary vegetation succession phase
(D) Permanent pasture and livestock grazing phase

2001

13. How is an agrosilvopastoral system structurally defined?
(A) Integration of trees, crops, and pasture/animals
(B) Integration of woody perennials and agricultural crops only
(C) Integration of pasture grasses and domesticated livestock only
(D) Integration of commercial aquaculture with intensive forestry

2002

14. Which allelopathic interaction exemplifies a negative complementary effect in agroforestry?
(A) Biological nitrogen fixation by associate leguminous tree species
(B) Upward hydraulic lift of soil water by deep-rooted canopy trees
(C) Excretion of phytotoxic phenolics inhibiting germination
(D) Amelioration of microclimate by shade reducing crop evapotranspiration

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2023

15. Analyze the following statements consisting of an Assertion (A) and a Reason (R), and select the correct option.
Assertion (A): Grasses adapted to heavy grazing often exhibit decumbent growth habits and basal meristems.
Reason (R): Basal meristems protect the growing points of grasses from being removed by grazing animals.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

16. The Sehima-Dichanthium grassland cover is primarily distributed in which region of India?
(A) High-altitude montane and temperate Himalayan regions
(B) The extreme arid zones of western Rajasthan
(C) Peninsular India including the Deccan Plateau
(D) The highly humid floodplains of the Brahmaputra river

2022

17. Which parameter is essential for calculating the carrying capacity of a rangeland?
(A) Total annual precipitation inputs divided by cumulative livestock biomass
(B) Usable forage production and daily animal dry matter needs
(C) The ecological ratio of highly palatable perennial to annual weeds
(D) The peak photosynthetically active radiation

field

2012

70. Consider the following statements on soil water dynamics:

I. Crop residue reduces the rate of surface evaporation.
II. Residue decreases water infiltration by blocking soil pores.
III. Conservation agriculture generally increases water-use efficiency (WUE).
IV. Matric potential is zero in completely dry soils.
V. Macropores dominate water flow under saturated conditions.

Which of the above statements are correct?
(A) I, III and V
(B) II, III and IV
(C) I, II, IV and V
(D) III, IV and V

2011

71. The shift from conventional tillage to zero tillage typically induces a weed flora transition from:
(A) Deep-rooted herbaceous perennials to strictly woody shrub species
(B) Large-seeded broadleaves to small-seeded annual grasses
(C) Annual grasses to large-seeded broadleaf weed species exclusively
(D) Terrestrial parasitic weeds to specialized aquatic weed populations

2011

72. Which agricultural practice is most likely to reduce the incidence of soil-borne necrotrophic diseases in a CA system?
(A) Continuous monocropping of a susceptible host
(B) Increasing irrigation frequency to waterlogging levels
(C) Implementing diverse crop rotations
(D) Applying high doses of raw, uncomposted manure

2013

73. A major economic benefit of utilizing a Zero-till drill in wheat cultivation after rice is:
(A) Complete and permanent elimination of the biological need for any chemical herbicides
(B) Significantly increasing the tractor power and horsepower requirements for draft operations
(C) Directly earning international carbon credits that match or exceed final harvested crop yields
(D) Savings in land preparation costs and ensuring timely sowing

2019

74. Which Land Capability Class is characterized by very severe limitations that restrict the choice of plants, require very careful management, or both, yet is still suitable for restricted cultivation?
(A) Class I
(B) Class IV
(C) Class VII
(D) Class VIII

2008

75. In wasteland classification, "waterlogged and marshy lands" are primarily caused by:
(A) High topographic elevation and steep mountain slopes
(B) Impeded drainage and high water tables
(C) Severe and unchecked wind-induced surface soil erosion
(D) Quaternary glacial retreat and active moraine movement

2009

76. During the "fallow phase" of shifting cultivation, what is the primary ecological objective?
(A) To restore fertility via succession and biomass buildup
(B) To rapidly prepare sloping forest land for permanent urban developments
(C) To completely eradicate all native, volunteer wild plant species
(D) To maximize short-term high-density commercial timber harvests

2011

77. Which system specifically refers to the deliberate retention or introduction of trees in pastures to benefit livestock?
(A) Silvopastoral system
(B) Agrisilviculture
(C) Aquaforestry
(D) Protein bank agroforestry

2018

78. In a tree-crop mixed system, the "competitive exclusion principle" suggests that:
(A) Tree and understory crop species perfectly share all localized growth resources without any biological conflict
(B) Highly dominant trees always yield completely to annual crops in competitive resource and moisture uptake
(C) Species with identical niches will compete to

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(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-3, R-2, S-4

2025
26. Which metric best captures the net greenhouse gas impact of an agricultural system over a 100-year horizon?
(A) Global Warming Potential (GWP)
(B) Total Carbon Transpiration Rate
(C) Canopy Photosynthetic Efficiency
(D) Soil Respiration Quotient

2017
27. Deep placement of nitrogen fertilizer in Conservation Agriculture primarily aims to reduce which loss mechanism?
(A) Biochemical nitrification processes taking place in the deeper anoxic soil zones
(B) Volatilization of ammonia from surface residues
(C) Physical fixation of ammonium cations by expandable silicate clay minerals
(D) Downward leaching of highly mobile nitrate anions well past the active root zone

2013
28. Which physical property of soil is most directly responsible for the retention of plant-available water against gravity?
(A) Total macroporosity of the soil
(B) Capillarity driven by matric potential
(C) Gravimetric bulk density of aggregate soils
(D) Physical particle size distribution of mineral fractions

2002
29. The concept of "ecological footprinting" in agriculture measures which parameter?
(A) Land and water area needed for resources and waste assimilation
(B) Cumulative physical fresh and dry weight of all agricultural crops harvested per hectare
(C) Maximum vertical depth of functional crop root penetration in highly compacted subsoils
(D) Net annual carbon sequestration rate minus the total equivalent methane emission rate

2016
30. Consider the following combinations regarding shifting cultivation terminology:
I. Jhum is practiced in Northeast India.
II. Podu is practiced in Andhra Pradesh/ Odisha.
III. Bewar is practiced in Madhya Pradesh.
IV. Ponam is practiced in Rajasthan.
V. Milpa is a term used in Central America.
Which of the above combinations is/are INCORRECT?
(A) I, II and IV
(B) III, IV and V
(C) I, II, III and V
(D) IV

NODIA

2019
31. Which definition best describes an 'unculturable wasteland'?
(A) Cultivated land heavily degraded by recent anthropogenic activities but economically recoverable
(B) High-fertility fallow land left completely unseeded for at least one full cropping season
(C) Natural forest land legally diverted and cleared for heavy industrial or infrastructural use
(D) Land undeveloped for vegetation due to extreme physical limits

2008
32. In agroforestry resource partitioning, the "safety-net role" refers to what phenomenon?
(A) Canopy trees providing essential structural and physical support to climbing companion crops
(B) Dense tree crowns and canopies protecting fragile understory crops from direct hail impact damage
(C) Deep tree roots recycling nutrients leaching below the crop root zone
(D) Long-term socio-economic financial insurance provided by the planned sale of high-value timber

2025
33. The Dichanthium-Cenchrus-Lasiurus grass cover type is primarily adapted to which climatic zone in India?
(A) Humid and sub-humid tropical climates
(B) Arid and semi-arid regions
(C) Temperate and sub-alpine meadow regions
(D) Low-lying saline coastal wetlands

2023
34. What is a primary indicator of severe overgrazing in a rangeland ecosystem?
(A) Increased dominance of palatable perennial grasses
(B) Enhanced soil organic carbon accumulation
(C) Increased litter accumulation leading to a thicker A-horizon

CHAPTER 08
Sustainable Land Use Systems

2013

1. Which dimension is NOT considered a primary pillar of sustainable agriculture?
(A) Ecological and environmental viability
(B) Technological singularity
(C) Economic profitability and net returns
(D) Social equity and gender inclusivity

2019

2. Which mathematical construct is typically utilized to compute the Soil Quality Index (SQI)?
(A) Logarithmic decay functions of soil organic matter
(B) Exponential growth curves of soil microbial biomass
(C) Polynomial regression equations of crop yield over time
(D) Linear combinations of weighted soil indicators

2022

3. What represents a core operational principle of Conservation Agriculture (CA)?
(A) Maintenance of a permanent or semi-permanent organic soil cover
(B) Deep moldboard plowing every alternate season
(C) Monoculture of high-yielding cereal varieties
(D) Complete eradication of soil microbial populations prior to sowing

2022

4. Which agricultural practice most significantly contributes to anthropogenic methane emissions?
(A) Excessive nitrogen fertilizer application in dryland wheat
(B) Systematic minimum tillage operations in semi-arid regions
(C) Continuous flooding in lowland rice cultivation
(D) Diversified intercropping of grain legumes with cereals

2024

5. Under zero-tillage Conservation Agriculture, what nutrient phenomenon is commonly observed over time?
(A) Stratification of immobile nutrients near the soil surface
(B) Uniform distribution of phosphorus and nitrogen throughout the soil profile
(C) Accelerated depletion of available potassium in the topsoil layer
(D) Complete downward leaching of all essential micro and macronutrients

2010

6. How does crop residue cover primarily influence soil water conservation?
(A) By significantly increasing soil surface albedo and reducing plant transpiration
(B) By actively promoting capillary water rise from shallow water tables
(C) By initiating rapid surface runoff flow during high-intensity rainfall events
(D) By reducing raindrop impact energy and surface soil evaporation

2003

7. Conservation agriculture typically alters weed seed bank dynamics by causing what shift?
(A) A rapid transition towards deep-rooted perennial weeds exclusively
(B) Increased dominance of surface-germinating annual grass weeds
(C) Complete elimination of broadleaf weed seeds
(D) Uniform distribution of weed seeds throughout the plow layer

2001

8. In Conservation Agriculture, epidemiological changes often favor which type of pests due to residue retention?
(A) Airborne obligate fungal pathogens requiring living hosts
(B) Highly migratory defoliating insect pests of major crops
(C) Debris-borne necrotrophic fungal pathogens
(D) Phloem-feeding viral pathogens transmitted without insect vectors

2006

9. What is a primary socio-economic constraint limiting the rapid adoption of the Happy Seeder?

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2002

45. Arrange the following biomass materials in increasing order of their typical C:N ratio:
1. Alfalfa hay, 2. Sawdust, 3. Wheat straw, 4. Rotted farmyard manure.
(A) 1, 4, 3, 2
(B) 1, 3, 4, 2
(C) 4, 1, 3, 2
(D) 4, 3, 1, 2

2005

46. What fundamental physical principle explains water movement in unsaturated soil under crop residue?
(A) Fick's Law of multi-component gaseous and molecular diffusion
(B) Stokes' Law of spherical particle settling in viscous fluids
(C) Darcy's Law under matric and gravity gradients
(D) Poiseuille's Law for laminar water flow within strictly saturated pipes

2004

47. Which statement is INCORRECT regarding weed shift dynamics under Conservation Agriculture?
(A) Phalaris minor populations often decrease under long-term continuous zero-tillage wheat systems.
(B) Surface residue cover often physically suppresses small-seeded annual weed seedling emergence.
(C) Soil weed seed banks tend to concentrate heavily within the topmost 0-5 cm soil depth layer.
(D) Perennial weeds like Cyperus rotundus decrease under zero-tillage.

2023

48. What role do crop residue-herbicide interactions play in weed management under CA?
(A) Heavy crop residue cover uniformly and significantly enhances the efficacy of all pre-emergence herbicides
(B) Herbicides chemically and permanently bind with surface lignin molecules to form highly potent natural allelochemicals
(C) Residues intercept soil herbicides, lowering surface concentration
(D) Surface residues completely neutralize the herbicidal activity of post-emergence translocated chemical formulations

2003

49. The altered microclimate under crop residues in CA (higher moisture, moderated temperature) usually promotes which biological agent?
(A) Foliar spider mites requiring extremely dry and hot ambient conditions
(B) Entomopathogenic fungi and beneficial ground beetles
(C) Desert locusts and related highly migratory grasshopper species
(D) Sun-loving and heat-tolerant aphid species exclusively

2013

50. Consider the following statements on Conservation Agriculture machinery:
I. The Turbo Seeder requires complete residue removal before operation.
II. The Happy Seeder manages loose residue by flailing it and blowing it behind the seeding tines.
III. Zero-till drills are primarily designed for heavily tilled, clod-free seedbeds.
Which of the above statements is/are correct?
(A) I and II
(B) II
(C) II and III
(D) I and III

2007

51. Land Capability Class VI is best suited for:
(A) Pasture, woodland, or wildlife food/cover
(B) Intensive row-crop cultivation
(C) Occasional cropping with extreme conservation measures
(D) Complete urbanization and paving

2010

52. Which factor is recognized as a major anthropogenic driver of culturable wastelands in irrigated command areas?
(A) Systematic implementation of intentional, state-sponsored aforestation programs
(B) The successful field establishment of high-efficiency precision drip irrigation networks
(C) Over-irrigation leading to waterlogging and salinity
(D) Progressive structural depletion and collapse of deep, ancient confined aquifers

2006

53. Restorative models for degraded Jhum lands typically incorporate which strategy?
(A) Replacing natural fallows with nitrogen-fixing tree species
(B) Artificially increasing the frequency and

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intensity of the agricultural burning cycle
(C) Initiating the complete engineered paving of all degraded upland hill slopes
(D) Exclusive long-term reliance on inorganic chemical fertilizers without structural organic changes

2021
54. An agrisilvicultural system strictly excludes which of the following components?
(A) Annual cereal crops such as wheat or maize
(B) Highly structured woody tree perennials
(C) Leguminous grain and pulse crops
(D) Livestock or pasture for grazing

2009
55. Analyze the following statements consisting of an Assertion (A) and a Reason (R), and select the correct option.
Assertion (A): Pruning tree roots in agroforestry systems minimizes below-ground competition.
Reason (R): Root pruning physically separates the nutrient and water absorption zones of trees and crops.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014
56. What morphological feature of grasses allows them to recover rapidly from defoliation?
(A) Strong apical dominance mechanisms restricted entirely to the absolute shoot tip
(B) Extensive systems of highly developed, deep, woody soil-penetrating taproots
(C) Intercalary meristems at the leaf and internode bases
(D) Highly sensitive epigeal and cotyledonary seedling germination mechanisms

2003
57. The Phragmites-Saccharum-Imperata grass cover type is typically found in:
(A) Hyper-arid shifting desert sand dunes
(B) High-altitude cold alpine meadow zones
(C) Highly weathered lateritic rocky outcrop formations
(D) Wet, marshy, or low-lying waterlogged areas

2009
58. Deferred grazing in rangeland management is defined as:
(A) Delaying grazing on an area until key forage species have set seed
(B) Allowing continuous, year-round livestock grazing without any scheduled pasture rest periods
(C) Grazing all available herd livestock at extremely high stocking densities for one single day only
(D) Feeding domesticated livestock exclusively on green harvested forage inside confinement stalls

2012
59. What is a key determinant of the decomposition kinetics of agro-industrial residues?
(A) The exact geographical latitude and altitude of the field site
(B) The lignin to nitrogen ratio of the residue
(C) The color of the crop prior to harvest
(D) The average wind speed during the active residue decomposition phase

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2025
60. Consider the following statements regarding residue recycling:
I. Vermicomposting utilizes earthworms like Eisenia fetida.
II. Anaerobic composting typically produces higher temperatures than aerobic composting.
III. Biochar application generally increases soil cation exchange capacity (CEC).
IV. Aerobic composting requires maintaining a moisture level of around 10%.
Which of the above statements are INCORRECT?
(A) I and III
(B) II and IV
(C) I, II and IV
(D) III and IV

2019
61. In the context of crop-weed interactions, what is 'true allelopathy'?
(A) Direct release of toxic chemicals from a living plant to the environment
(B) Indirect release of toxic organic compounds during active microbial decomposition of crop residues
(C) Direct physical competition for essential growth factors like solar radiation, soil water, and nutrients
(D) Horizontal transmission of destructive phytopathogenic viral diseases from wild weeds to target crops

2018

62. Which parameter is a primary metric of biomass production in energy plantations?
(A) Leaf area index exclusively at the seedling stage
(B) Total grain yield per hectare
(C) Mean Annual Increment (MAI) of woody biomass
(D) Specific gravity of the root hairs

2019

63. How does computer vision aid in precision farming?
(A) By predicting long-term commodity and grain market prices based entirely on financial text analysis
(B) By automatically regulating complex chemical synthesis of inorganic fertilizers inside modern factories
(C) By actively modifying structural DNA sequences of crops through high-intensity external visual stimuli
(D) By identifying weed species or pest damage from images

2011

64. Automated irrigation decision support systems typically integrate IoT sensors to optimize:
(A) Directing maximum possible irrigation water application rates regardless of actual physiological crop needs
(B) Initiating uniform, unregulated flooding across all diverse agricultural field zones simultaneously
(C) Water-use efficiency (WUE) by irrigating exactly at the allowable depletion threshold
(D) Systematically reducing non-beneficial water evaporation losses from large, open distribution canals

2007

65. Match the Agroforestry classification basis in List I with its defining trait in List II.
List I: Agroforestry Classification Basis
P. Structural basis
Q. Functional basis
R. Socio-economic basis
S. Ecological basis
List II: Defining Trait
1. Categorization by protective vs. productive roles
2. Categorization by commercial, subsistence, or intermediate scales
3. Categorization by adaptation to specific climatic or soil zones
4. Categorization by the spatial and temporal arrangement of components
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

2024

66. The "ecological footprint" of an agricultural product is most negatively impacted by:
(A) Extensively using local, low-carbon organic nitrogen fertilizers and composts
(B) Systematically implementing minimum or zero conservation tillage practices
(C) Actively utilizing localized and engineered rainwater harvesting systems on farm
(D) Heavy reliance on carbon-intensive synthetic inputs

2001

67. Which of the following is considered an environmental advantage of Conservation Agriculture over conventional tillage?
(A) Enhanced aggregate stability leading to reduced water erosion
(B) Increased particulate matter in the atmosphere from residue burning
(C) Higher diurnal soil temperature fluctuations
(D) Greater runoff velocity during monsoon rains

2015

68. Nitrous oxide (N_2O) emissions in agriculture are predominantly driven by:
(A) Incomplete and inefficient combustion of petroleum fuel in farm tractors
(B) Anaerobic enteric fermentation occurring within the rumens of grazing animals
(C) Microbial nitrification and denitrification in soils
(D) Natural long-term geological weathering processes of primary silicate minerals

2003

69. To mitigate surface nitrogen volatilization in a CA system with heavy residue cover, the best application method is:
(A) Banding or injecting nitrogen below the residue
(B) Uniformly broadcasting granular urea fertilizers over the wet organic residue cover
(C) Directly applying highly soluble granular nitrate formulations onto dry surface residue
(D) Completely and permanently avoiding any form of inorganic nitrogen application in the

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intercepted by the canopy

2005

18. Residues with a high C:N ratio (e.g., $> 80{:}1$) typically undergo which process when incorporated into the soil?
(A) Rapid mineralization releasing available nitrogen
(B) Immediate humification without microbial intervention
(C) Volatilization of structural carbon
(D) Microbial immobilization of available soil nitrogen

2015

19. During the active thermophilic phase of aerobic composting, what is the primary biological activity?
(A) Rapid microbial breakdown of easily metabolizable carbon
(B) Enzymatic degradation of complex lignins and structural cellulose by mesophilic fungi
(C) Epigeic earthworms actively consuming and processing partially decomposed organic matter
(D) Anaerobic methanogenic archaea producing significant quantities of biogenic methane gas

2003

20. Consider the following statements regarding allelopathy:
I. Terpenoids are a major class of allelochemicals.
II. Allelochemicals are only released through root exudation.
III. Volatilization is a recognized pathway for allelochemical release in arid environments.
IV. Juglone from black walnut is a classic example of an allelochemical.
Which of the above statements are correct?
(A) I, II and IV
(B) I, III and IV
(C) II and III
(D) I and IV

2001

21. Which tree species is most commonly associated with Short-Rotation Intensive Culture (SRIC) for bioenergy?
(A) Populus deltoides (Poplar)
(B) Quercus robur (English Oak)
(C) Tectona grandis (Common Teak)
(D) Dalbergia sissoo (Indian Shisham)

2006

22. In the context of AI in agriculture, what is the primary function of a Convolutional Neural Network (CNN)?
(A) Forecasting long-term economic supply and demand trends in global grain markets
(B) Simulating and optimizing the genetic sequences of highly productive hybrid seeds
(C) Automatically regulating the hydraulic pressure and flow rates in tractor engines
(D) Processing and classifying spatial crop health images

2022

23. What is a key advantage of utilizing drone mapping for real-time crop health monitoring?
(A) It eliminates the need for any ground-truthing or field validation
(B) It provides high spatial and temporal resolution multispectral imagery
(C) It actively applies fertilizers directly from the drone's imaging sensors
(D) It replaces the need for soil moisture sensors entirely

2022

24. A System Sustainability Index (SSI) approaching zero implies what condition?
(A) The agricultural system is highly sustainable and stable
(B) The system's output requires virtually no external inputs
(C) The system is highly unsustainable and degrading rapidly
(D) The ecological footprint is completely neutral

2012

25. Match the Conservation Agriculture equipment in List I with its primary functional characteristic in List II.

List I: Conservation Agriculture Equipment
P. Zero-till drill
Q. Happy Seeder
R. Turbo Seeder
S. Laser Land Leveler

List II: Functional Characteristic
1. Sows through standing residue by shredding and retaining it as mulch
2. Precision grading to improve water application efficiency
3. Sows seeds directly without major residue clearance capabilities
4. Sows seed and fertilizer simultaneously while actively managing heavy loose residue

(A) P-2, Q-1, R-4, S-3

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exclusion
(D) Direct chemical allelopathy effectively prevents all other physical and ecological forms of plant competition

2008
79. The physiological adaptation that allows certain range grasses to withstand severe drought is:
(A) Extremely shallow adventitious root systems that are strictly confined to the top 1 cm of dry soil
(B) An obligate and absolute physiological requirement for deep canopy shade to survive
(C) Continuous, uncontrolled rapid transpiration rates regardless of declining soil water potentials
(D) C_4 pathway and leaf rolling to reduce stomatal conductance

2009
80. Select the correct order of the general decomposition phases of organic residues.
(A) Leaching of solubles → Fragmentation by meso-fauna → Chemical alteration by microbes
(B) Chemical alteration → Leaching → Fragmentation
(C) Fragmentation → Chemical alteration → Leaching
(D) Leaching → Chemical alteration → Fragmentation

2012
81. Rotational grazing improves rangeland sustainability primarily by:
(A) Strategically forcing grazing livestock to consume unpalatable or highly poisonous weeds
(B) Providing pastures rest and recovery periods before regrazing
(C) Concentrating livestock excreta and manure in a single, unmanaged, immovable paddock location
(D) Completely eliminating the economic need for temporary or permanent paddock fencing infrastructure

2003
82. Which ratio is widely used as a reliable predictor of the net mineralization or immobilization of nitrogen from crop residues?
(A) Cellular Lignin:Cellulose structural ratio
(B) Total inorganic Potassium:Phosphorus ratio
(C) Elemental Hydrogen:Oxygen stoichiometric ratio
(D) Carbon:Nitrogen (C:N) ratio

2022
83. The process of vermicomposting relies heavily on the synergistic relationship between earthworms and:
(A) Microorganisms that predigest organic materials
(B) Host-specific pathogenic plant viruses within the substrate
(C) Photosynthetic eukaryotic green algae in wet conditions
(D) Nitrogen-fixing cyanobacteria functioning exclusively in aquatic zones

2004
84. Which environmental condition significantly enhances the volatilization of allelochemicals from plant leaves?
(A) Consistently high relative humidity and extremely low ambient air temperatures
(B) Heavily flooded, anoxic, and waterlogged soil conditions
(C) High temperatures and arid conditions
(D) Deep, insulating dense snow cover over vegetation

2011
85. Arrange the AI/ML processes in the correct sequence for an automated weed detection system.
1. Feature extraction by CNN layers
2. Image acquisition via drone or rover
3. Output classification (Weed vs. Crop)
4. Application of targeted herbicide

(A) 2, 1, 3, 4
(B) 1, 2, 3, 4
(C) 2, 3, 1, 4
(D) 3, 1, 2, 4

2017
86. Short-Rotation Intensive Culture (SRIC) forestry primarily aims to maximize:
(A) Yield of high-quality select hardwoods and timber for luxury furniture manufacturing
(B) Commercial harvesting of diverse non-timber forest products like natural plant resins and gums
(C) Accelerating the conservation and biodiversity of structural climax forest climax species
(D) Rapid production of woody biomass for energy or pulp

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2019

119. Pest population dynamics under Conservation Agriculture (CA) can be complex because residues:

(A) Act exclusively as a physical and chemical toxic barrier to all invasive insect species

(B) Provide a microclimate habitat for both overwintering pests and beneficial predatory arthropods

(C) Reflect high amounts of solar radiation, effectively blinding all incoming flying insect pests

(D) Emit specific high-frequency ultrasonic vibrations that deter herbivorous insects from feeding

2001

120. Which feature distinguishes the Turbo Seeder from the conventional Zero-till drill?

(A) It requires a thoroughly prepared, deeply pulverized seedbed using multiple tractor tillage passes

(B) It strictly broadcasts crop seeds over the soil surface without achieving any direct soil penetration

(C) It incorporates active rotary blades that cut a narrow slit through heavy, loose surface residue

(D) It is engineered exclusively for planting specialized tubers like potatoes in sandy soils

2013

121. In designing an alternate land use system for Class VII land, the most appropriate choice is:

(A) Intensive double-cropping of rice and wheat

(B) Commercial vegetable farming with heavy tillage

(C) Deep excavation for aquaculture ponds

(D) Silvopasture or strict forestry

2006

122. The term "culturable wasteland" implies that the land:

(A) Has potential for vegetative cover development but is currently degraded or underutilized

(B) Cannot support any form of vegetative growth or agricultural crop under any circumstances

(C) Is currently managed under high-input, high-intensity precision agricultural systems

(D) Is completely covered by urban concrete infrastructure, preventing any biological use

2023

123. The rapid decline in soil fertility during the cropping phase of Jhum cultivation is primarily caused by:

(A) Continuous over-application of heavy synthetic chemical fertilizers and acidifying agents

(B) Intense soil erosion, leaching of ash nutrients, and rapid oxidation of soil organic matter

(C) Deep mechanical plowing and intensive soil inversion using heavy motorized agricultural machinery

(D) Excessive biological nitrogen fixation carried out by aggressive invasive leguminous weeds

2012

124. An agroforestry system that mixes trees, crops, and pasture in a temporal sequence rather than simultaneously is known as:

(A) A spatial arrangement where trees and crops occupy different zones of the field simultaneously

(B) A rotational arrangement such as traditional shifting cultivation or managed improved fallows

(C) An interpolated arrangement characterized by high-density, random planting of multi-tier species

(D) An aquatic arrangement designed primarily to integrate timber production with commercial fisheries

2013

125. The release of juglone by black walnut trees causing toxicity to surrounding plants is a classic example of:

(A) Allelopathy

(B) Competition for light

(C) Parasitism

(D) Symbiosis

2024

126. Which morphological trait is least advantageous for a grass species subjected to heavy grazing?

(A) Prostrate growth habit

(B) High ratio of vegetative to reproductive stems

(C) Elevated apical meristems on elongated internodes

(D) Extensive rhizomatous root systems

2022

127. The grasslands of the Himalayan region are primarily dominated by:

(A) Sehima-Dichanthium tropical grass cover types

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(C) A is true but R is false.
(D) A is false but R is true.

2004

96. Under Conservation Agriculture, what is the primary risk associated with retaining infected crop residues on the soil surface?
(A) Significantly increased incidence of phytopathogenic viral diseases transmitted by dry wind currents
(B) Immediate, acute toxic death of all beneficial and non-beneficial soil mesofauna populations
(C) Carryover of inoculum for necrotrophic fungal diseases
(D) Complete biochemical and heat sterilization of the organic topsoil layer within one season

2004

97. The socio-economic constraint of "fragmented land holdings" affects CA adoption by:
(A) Physically and inherently increasing the biological yield potential per unit land hectare
(B) Making individual purchase of large CA machinery unviable
(C) Completely reducing the agronomic need for any form of mechanical farm mechanization
(D) Economically forcing smallholder farmers to switch entirely to slash-and-burn shifting cultivation

2011

98. Land Capability Class VIII is characterized by:
(A) Highly productive deep, level, and well-drained alluvial soil profiles
(B) High ecological suitability for continuous, uninhibited intensive row cropping
(C) Being strictly and legally reserved for intensive inland freshwater aquaculture projects
(D) Extreme limits making it unsuitable for commercial plants

2021

99. "Salt-affected lands" are a category of wasteland primarily mapped using:
(A) Multispectral imagery identifying high surface reflectance
(B) Highly sensitive ground penetrating radar systems measuring subsurface salinity profiles
(C) Historical land tax records and traditional cadastral maps preserved by local governments
(D) High-frequency artificial seismic surveys measuring regional geological structural faults

2025

100. Consider the following statements regarding Jhum cultivation:
I. It is an ecologically sustainable practice under a 2-year cycle.
II. Soil degradation occurs rapidly during the cropping phase.
III. It involves the complete removal of stumps to allow tractor plowing.
IV. It relies on the ash from burning to provide a temporary nutrient flush.
Which of the above statements are INCORRECT?
(A) I and III
(B) II and IV
(C) I and III
(D) III and IV

2022

101. Which term describes an agroforestry system designed specifically to produce leafy fodder for livestock?
(A) Protein bank
(B) Shelterbelt
(C) Taungya system
(D) Aquaforestry

2025

102. In tree-crop interactions, the "complementary effect" is maximized when:
(A) The spatial distribution of tree and crop roots heavily overlaps in the topsoil
(B) Tree and crop resource demands peak at the exact same time
(C) Trees produce dense shade over a strictly sun-loving crop
(D) Trees utilize resources that the crop cannot access (e.g., deep soil water)

2003

103. The morphology of grazing-tolerant grasses typically includes:
(A) Elevated apical meristems
(B) Tillering from basal axillary buds
(C) Large, broad, thin leaves
(D) Strict annual life cycles without vegetative reproduction

2012

104. Which grass species is a dominant component of the semi-arid grasslands in the Indian desert region?
(A) Phalaris minor

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(B) Echinochloa crus-galli
(C) Lasiurus sindicus
(D) Arundo donax

2006

105. Match the rangeland ecology term in List I with its definition in List II.

List I: Term

P. Carrying Capacity
Q. Stocking Rate
R. Overgrazing
S. Animal Unit (AU)

List II: Definition

1. The actual number of animals grazing a specific area for a specific time
2. A standard measure based on a 1000-lb beef cow's dry matter requirement
3. The maximum animal numbers a rangeland can support sustainably
4. Continued heavy grazing that exceeds the recovery capacity of the forage

(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-4, R-1, S-3

2008

106. Which parameter best determines the decomposition speed of agro-residues when the C:N ratio is constant?

(A) Lignin content
(B) Potassium content
(C) Color of the residue
(D) Length of the harvested stem

2012

107. Biochar application improves soil properties primarily due to its:

(A) High concentration of organic nitrogen and soluble phosphorus that are immediately available to crops
(B) Highly porous structure and large surface area, increasing both CEC and water retention
(C) Rapid biodegradability under aerobic conditions, leading to the swift release of key humic substances
(D) Ability to drastically lower soil pH in alkaline zones while neutralizing toxic aluminum concentrations

2009

108. Which specific crop-weed allelopathic interaction is well documented in agronomy?

(A) Wheat residues releasing phenolic compounds that actively inhibit Phalaris minor germination
(B) Sorghum root exudates (sorgoleone) that suppress the growth of certain broadleaf weeds
(C) Rice residues releasing organic compounds that directly promote Echinochloa seed germination
(D) Maize root exudates acting as a highly toxic universal herbicide against all monocot weeds

NODIA

2016

109. What is the primary characteristic of tree species chosen for Short-Rotation Intensive Culture (SRIC)?

(A) Fast juvenile growth and ability to coppice
(B) Extremely slow growth and high wood density
(C) Requirement for undisturbed climax forest conditions
(D) Complete resistance to all known pathogens

2023

110. Given below are some statements regarding IoT in agriculture:

I. IoT systems rely on sensor nodes deployed in the field.
II. IoT architecture requires cloud or edge computing for data analysis.
III. IoT systems cannot operate without continuous human manual input.
IV. Automated irrigation is a key application of IoT.
V. IoT sensors can measure microclimatic variables like soil moisture and canopy temperature.

Which of the above statements are correct?

(A) I, II, III and V
(B) I, II, IV and V
(C) II, III, IV and V
(D) I, III, IV and V

2018

111. Precision farming differs from traditional farming primarily by:

(A) Treating large agricultural regions with completely uniform chemical application rates
(B) Eliminating the integration of global positioning systems and modern computerized technology
(C) Focusing agricultural production exclusively on genetic engineering and crop modification
(D) Managing agricultural practices at a highly

localized, spatially variable, site-specific level

2023

112. The social dimension of sustainable agriculture critically evaluates:
(A) The gross domestic product and macroeconomic growth of the entire agricultural sector
(B) The chemical purity and long-term toxicological safety of local groundwater reserves
(C) Social equity, household food security, and the well-being of farming communities
(D) The operational speed, energy efficiency, and fuel consumption of autonomous machinery

2011

113. A System Sustainability Index (SSI) incorporates both:
(A) Historical crop commodity prices and long-term future financial market predictions
(B) Agronomic yield trends and systematic changes in soil quality indicators over time
(C) Initial seed germination percentages and seasonal weed biomass accumulation rates
(D) Tractor fuel consumption rates and energy-intensive fertilizer manufacturing costs

2017

114. Which effect does conventional tillage typically have on the soil profile?
(A) It permanently lowers regional groundwater tables, leading to rapid desertification of arable land
(B) It builds a structured, highly stable organic horizon on the soil surface over consecutive seasons
(C) It halts the microbial mineralization of organic matter by completely eliminating soil oxygen access
(D) It disrupts soil pores, causing a temporary increase in porosity followed by compaction and crusting

2008

115. Soil carbon sequestration under Conservation Agriculture (CA) is largely attributed to:
(A) Physical protection of organic matter within stable micro-aggregates
(B) Chemical transformation of carbon into diamond-like structures
(C) Volatilization of carbon into the lower atmosphere
(D) The continuous plowing of crop residues into the deep subsoil

2014

116. Applying nitrogen fertilizer strictly to the soil surface without incorporation in a Conservation Agriculture (CA) system is most likely to result in:
(A) Complete biological immobilization of nitrogen by deep-burrowing earthworms
(B) Immediate chemical conversion of nitrogen into insoluble organic macromolecules
(C) High nutrient losses via ammonia volatilization, particularly when using urea
(D) Deep leaching of nitrate directly into local groundwater tables within hours

2001

117. Water-Use Efficiency (WUE) under Conservation Agriculture (CA) is generally higher than conventional systems due to:
(A) An increase in transpiration alongside a reduction in evaporation, raising the overall $\frac{T}{E}$ ratio
(B) A reduction in plant transpiration coupled with a major increase in direct soil-surface evaporation
(C) Complete elimination of physiological transpiration by maintaining high localized relative humidity
(D) Maximum allowable surface runoff and rapid drainage of irrigation water across field boundaries

2007

118. Which statement represents an inference-based conclusion about weed management in Conservation Agriculture (CA)?
(A) Soil-applied pre-emergence herbicides display reduced efficacy because they are physically intercepted and bound by thick surface crop residues.
(B) Weed seed populations in the soil profile will undergo complete depletion and entirely stop germinating after five continuous years of CA.
(C) Manual hand weeding remains the sole mathematically and economically viable weed management strategy for smallholder farmers adopting CA.
(D) Since mechanical cultivation is absent, integrated weed management using diverse crop rotations and competitive cultivars becomes essential.

NODIA

livestock and soil respiration
(B) Total surface land area occupied by farm buildings and infrastructure
(C) Speculative valuation of cryptocurrency assets owned by the farm operator
(D) Upstream energy embedded in chemical fertilizer and pesticide production

2001

137. Which physical parameter is directly improved by the retention of crop residues in Conservation Agriculture (CA), reducing runoff?
(A) Bulk density
(B) Soil pH
(C) Cation exchange capacity
(D) Infiltration rate

2008

138. The primary mechanism of soil organic carbon sequestration is the transformation of plant litter into:
(A) Stable organo-mineral complexes and recalcitrant humic molecules
(B) Soluble monosaccharides and highly unstable, easily oxidizable sugars
(C) Gaseous hydrocarbons and volatile organic compounds released to the air
(D) Mineralized compounds consisting of inorganic carbonates exclusively

2017

139. Which biological change typically occurs in the soil profile under long-term conservation agriculture?
(A) Total elimination of earthworms
(B) A shift toward a fungally-dominated microbial community
(C) A shift toward a bacterially-dominated microbial community exclusively
(D) Complete cessation of all biological respiration

2003

140. How does a mulch layer affect soil moisture physics during the hot summer?
(A) It lowers the surface albedo, which maximizes solar absorption and direct soil heat flux
(B) It decouples the surface from turbulent atmospheric boundaries, reducing vapor gradients
(C) It increases the sensible heat flux downward while accelerating lateral heat conduction
(D) It activates rapid capillary action, pumping liquid moisture from the deeper subsoil layers

2021

141. The seed bank dynamics in Conservation Agriculture (CA) systems differ from conventional systems because:
(A) Surface-retained seeds show rapid initial emergence but undergo high predation and decay rates
(B) Deeply buried weed seeds enter long-term dormancy cycles, avoiding any direct exposure to predators
(C) Weed seeds completely lose viability and fail to germinate because of anaerobic conditions
(D) Surface seeds undergo genetic mutations due to specialized compounds released by the residue layer

2021

142. Soil-borne diseases like Rhizoctonia root rot may increase under Conservation Agriculture (CA) because:
(A) The fungal pathogen requires open, dry atmospheric pathways to complete its airborne spore dispersal
(B) The continuous lack of soil inversion eliminates essential organic matter substrates from the soil
(C) Higher soil moisture and cooler temperatures under surface residue favor active fungal proliferation
(D) Decomposition of the surrounding residue releases chemical compounds acting as a natural fungicide

2015

143. Which of the following is a direct economic advantage of using a Zero-till drill?
(A) Increased fuel consumption
(B) Necessity to purchase a larger tractor
(C) Decreased crop yield
(D) Reduction in turnaround time between crops

2014

144. In Land Capability Classification, Class I to IV lands are distinguished from Class V to VIII lands primarily by:
(A) Their geographical latitude and localized regional orientation
(B) Their private ownership status versus public community ownership
(C) Their biological capability to support cultivated arable crops safely
(D) Their spatial distance from major high-density urban markets

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(B) Dichanthium-Cenchrus-Lasiurus dry zone types
(C) Mangrove swamp estuarine halophytic grass types
(D) Themeda-Arundinella temperate alpine types

2023

128. What does "carrying capacity" define in rangeland management?
(A) The maximum weight a tractor can carry on the pasture
(B) The total water volume the soil can hold
(C) The maximum number of grazing animals the land can sustain without degradation
(D) The absolute minimum number of animals required to prevent bush encroachment

2003

129. Crop residues with high lignin and polyphenol contents decompose slowly because:
(A) They are highly soluble in water, leaching away rapidly before local microorganisms can colonize them
(B) They physically complex with proteins, rendering them resistant to rapid microbial enzymatic breakdown
(C) They actively release extreme metabolic heat during hydration, killing surrounding beneficial bacteria
(D) They are primarily composed of simple, short-chain carbohydrates that suppress fungal spore growth

2003

130. During anaerobic composting (e.g., biogas slurry generation), the terminal carbon byproduct is primarily:
(A) Pure carbon dioxide
(B) Carbon monoxide
(C) Carbon tetrachloride
(D) Methane (CH_4)

2019

131. Which release pathway is common for terpenoid allelochemicals in arid environments?
(A) Volatilization into the atmosphere
(B) Root exudation into water
(C) Leaching from decaying roots
(D) Transportation via insect vectors

2016

132. Biomass production metrics in Short-Rotation Intensive Culture (SRIC) are often expressed in terms of:
(A) Grams of fresh weight per milliliter of water
(B) Standard bushels of grain yield per acre of land
(C) Dry tons of woody biomass per hectare per year
(D) Standard straw bales harvested per linear foot

2024

133. Artificial Intelligence applications in agriculture utilize Neural Networks primarily to:
(A) Recognize complex patterns in datasets to predict crop yields from environmental variables
(B) Mechanically operate harvester blades to physically gather field crops without human guidance
(C) Optimize photovoltaic cell orientation to maximize electricity generated from solar panels
(D) Modulate fuel injection timing to control the internal combustion rate in diesel engines

2009

134. Drone mapping in precision agriculture often uses NDVI (Normalized Difference Vegetation Index), which relies on sensing which two light bands?
(A) Ultraviolet and X-ray
(B) Blue and Gamma
(C) Green and Far-Infrared
(D) Red and Near-Infrared (NIR)

2012

135. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R):
Assertion (A): Deep placement of fertilizers is often recommended in zero-tillage systems.
Reason (R): Zero-tillage results in nutrient stratification, leaving immobile nutrients stranded in the dry surface layer where root activity is low during droughts.
In light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2022

136. The ecological footprinting of a farming system does NOT account for:
(A) Direct greenhouse gas emissions from

pores
(D) Post-harvest biological decay of mature weed seeds

2001
155. Biomass energy from Short-Rotation Intensive Culture (SRIC) is considered "carbon neutral" because:
(A) Thermochemical conversion during burning emits zero gaseous carbon dioxide to the air
(B) Carbon dioxide released in burning equals carbon fixed during the growth phase of the trees
(C) Hardwood structures physically sequester atmospheric carbon compounds permanently after harvest
(D) All mechanized harvesting and transport equipment runs exclusively on green hydrogen fuel

2002
156. In Machine Learning, what defines "supervised learning" as used in crop disease classification?
(A) The model explores unstructured agricultural inputs to find hidden patterns without any target variables
(B) The model is trained on labeled data where targets (e.g. healthy vs diseased) are explicitly provided
(C) A software engineer manually codes every decision path, rule, and threshold parameter into the system
(D) The navigation controller steers an autonomous agricultural tractor along pre-mapped path coordinates

2009
157. Automated irrigation systems based on IoT utilize which parameter to determine real-time crop water stress?
(A) Canopy temperature-based crop water stress indexes
(B) Historical regional precipitation averages since 1950
(C) Visual manual counts of temporary leaf wilting patterns
(D) Gravitational variations linked to the monthly lunar cycle

2011
158. Which parameter is a core component of the social dimension in the Pillars of Sustainable Agriculture?
(A) Net farm profit margins and annual economic return rates
(B) Soil organic matter content and aggregate structural stability
(C) Fair agricultural labor practices and rural community resilience
(D) Tractor horsepower efficiency and lower fuel consumption rates

2008
159. A declining System Sustainability Index (SSI) over a 10-year period in a rice-wheat system most strongly suggests:
(A) An exponential increase in net seasonal farm profit margins
(B) Perfect ecological homeostasis across all physical resources
(C) Complete elimination of competitive annual weed populations
(D) Yield stagnation or decline despite stable or increasing inputs

2009
160. Which statement is an INCORRECT characteristic of Conservation Agriculture?
(A) It promotes minimum mechanical soil disturbance through direct seeding.
(B) It encourages economically viable crop diversification using rotations.
(C) It requires the incorporation of all crop residues into the plow layer.
(D) It aims to improve soil biological activity and micro-organism diversity.

2007
161. Agricultural practices contribute significantly to which specific greenhouse gas through the use of synthetic nitrogenous fertilizers?
(A) Methane (CH_4)
(B) Nitrous oxide (N_2O)
(C) Sulfur hexafluoride (SF_6)
(D) Chlorofluorocarbons (CFCs)

2022
162. How does the concept of "nutrient stratification" affect phosphorus management in zero-tillage?
(A) Phosphorus becomes highly mobile in the solution and leaches rapidly into ground aquifers
(B) Phosphorus undergoes gaseous conversion and is completely volatilized into the dry atmosphere
(C) Phosphorus is distributed evenly down to the active rooting depth through capillary water flow
(D) Phosphorus accumulates near the soil surface, limiting crop uptake if that top layer

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2013

145. Match the Wasteland category (List I) with its primary driver/characteristic (List II):

List I: (Wasteland Category)

P. Gullied/Ravenous land
Q. Saline/Alkaline land
R. Shifting cultivation areas
S. Degraded pastures

List II: (Primary Driver/Characteristic)

1. Anthropogenic burning and short fallow cycles
2. Overgrazing and exceedance of carrying capacity
3. Intense concentrated surface water runoff and erosion
4. Poor drainage and high evaporation in semi-arid irrigated zones

(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2021

146. Which regional nomenclature for shifting cultivation is correct?
(A) Jhum - Western Ghats
(B) Bewar - Northeast India
(C) Valre - Punjab
(D) Podu - Andhra Pradesh

2011

147. A shelterbelt is primarily an example of which type of agroforestry system functional category?
(A) Protective
(B) Strictly productive
(C) Subsistence
(D) Agrosilvopastoral

2010

148. Allelopathic interference in tree-crop interactions differs from resource competition because allelopathy involves:
(A) Direct biological depletion of key available water pools
(B) Interception of solar radiation by shading lower canopies
(C) Release of active chemical inhibitors into the environment
(D) Mechanical space restriction via dense physical root systems

2012

149. The fundamental morphological unit of a grass plant is the:
(A) Tiller
(B) Taproot
(C) Cotyledon
(D) Stipule

2001

150. Which ecological region is the natural habitat for the Dichanthium-Cenchrus-Lasiurus grass cover?
(A) High-altitude cold humid zones of the Eastern Himalayas
(B) Tropical maritime ecosystems of the Andaman Islands
(C) Evergreen rain forests located along the Western Ghats
(D) Arid and semi-arid plains of Western and Central India

2009

151. An indicator of a deteriorating rangeland ecosystem due to overgrazing is:
(A) Steady expansion in the basal cover of highly productive climax grass species
(B) Rapid invasion by unpalatable, toxin-producing weeds and thorny woody shrubs
(C) Measurable increases in soil infiltration capacity and organic carbon content
(D) Uniform decreases in soil bulk density and compaction within root zones

2011

152. Which residue component represents the highest resistance to microbial decomposition?
(A) Hemicellulose
(B) Starches
(C) Lignin
(D) Simple proteins

NODIA

2004

153. What is the primary role of the turning process in aerobic composting?
(A) To lower compost temperature permanently and stop any further heating
(B) To heat the pile beyond survival thresholds to completely kill microbial life
(C) To chemical modify organic fractions and increase the carbon-to-nitrogen ratio
(D) To reintroduce atmospheric oxygen and guarantee highly uniform decomposition

2013

154. Which biochemical process is responsible for producing sorgoleone, a potent allelochemical in sorghum?
(A) Active biosynthesis and exudation from root hairs
(B) Photochemical synthesis inside fully expanded leaves
(C) Passive foliar transpiration via open stomatal

2011

87. In precision agronomy, Artificial Neural Networks (ANN) are primarily utilized as:
(A) Electro-mechanical and hydraulic actuator components used inside autonomous tractors
(B) Non-linear statistical data tools for yield prediction
(C) High-precision physical electro-chemical sensors measuring soil pH directly in situ
(D) Specialized chemical enzyme catalysts utilized for accelerated inorganic fertilizer breakdown

2003

88. A significant reduction in the ecological footprint of an agricultural system can be achieved by:
(A) Transitioning from rainfed to fully pumped groundwater irrigation
(B) Increasing the frequency of deep plowing
(C) Substituting synthetic nitrogen with biologically fixed nitrogen
(D) Expanding the physical distance between farm and market

2015

89. Which mechanism explains why Soil Quality Index (SQI) is considered a dynamic parameter?
(A) It strictly and exclusively measures inherent, static, unchangeable soil physical properties like soil texture
(B) It relies solely and directly on underlying geological parent rock and bedrock geochemistry
(C) It is only measured on regional scales once every century by national geological surveys
(D) It includes management-sensitive microbial and carbon indicators

2017

90. Consider the following principles of Conservation Agriculture:
I. Minimum soil disturbance
II. Permanent soil cover
III. Strict monocropping to standardize residue
Which of the above principles is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2021

91. The conversion of a conventional tilled field to zero-tillage generally alters soil bulk density in which way during the initial transitional years?
(A) Significant, rapid and immediate decrease in cumulative soil bulk density values
(B) Slight increase or stabilization in surface bulk density
(C) Complete structural elimination and breakdown of all active soil aggregates
(D) Artificial conversion of the soil bulk density parameters to near zero values

2006

92. Which gas has the highest Global Warming Potential (GWP) per molecule over a 100-year timescale?
(A) Carbon dioxide (CO_2)
(B) Nitrous oxide (N_2O)
(C) Methane (CH_4)
(D) Oxygen (O_2)

2014

93. Nutrient stratification in zero-tillage requires farmers to adapt by:
(A) Using drills to band immobile nutrients near seed rows
(B) Uniformly broadcasting all soluble and insoluble fertilizers directly on the surface residue
(C) Switching agronomic practices entirely to foliar spray feeding for all major macronutrients
(D) Completely and systematically ignoring phosphorus and potassium application protocols entirely

2022

94. The maximum height of capillary rise of water from a water table is inversely proportional to:
(A) The overall magnitude of the local matric suction gradient vector
(B) The dynamic saturated hydraulic conductivity of the local soil profile
(C) Soil pore radius
(D) The total vertical distance and depth of the localized water table

2019

95. Analyze the following statements consisting of an Assertion (A) and a Reason (R), and select the correct option.
Assertion (A): Crop residues on the soil surface can intercept pre-emergence herbicides.
Reason (R): Herbicides bound to crop residues are permanently deactivated and cannot reach the soil.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.

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dries out

2001

163. Crop residues improve water-use efficiency (WUE) primarily by:
(A) Reducing surface soil evaporation, conserving more profile moisture for transpiration
(B) Increasing deep percolation losses to recharge water tables below the crop rooting depth
(C) Forcing crop root systems to absorb and metabolize available soil water at faster rates
(D) Halting all gaseous exchange of oxygen and carbon dioxide at the soil-atmosphere boundary

2016

164. In Conservation Agriculture (CA), a shift towards perennial weed species is often observed because:
(A) Standard pre-emergence herbicides selectively target annual weed species while leaving perennials unharmed
(B) Surface crop residues undergo specialized decay processes that directly nourish underground perennial tubers
(C) The continuous lack of deep soil inversion fails to disrupt vegetative perennating structures and rhizomes
(D) Perennial weed seeds are highly photoblastic and can only undergo germination at the bare soil surface

2016

165. A "disease suppressive soil" developing under long-term Conservation Agriculture (CA) is primarily attributed to:
(A) Antagonistic and competitive interactions from a highly active, diverse soil microbiome
(B) Chemical sterilization and direct toxic effects resulting from long-term herbicide use
(C) Heavy structural weight of surface crop residues physically crushing fungal spores
(D) Complete absence of soil capillary moisture which prevents pathogen growth and survival

2006

166. A major socio-economic constraint preventing the adoption of the Happy Seeder among smallholder farmers is:
(A) Strict regulatory frameworks that mandate a minimum operational scale of 500 contiguous hectares of crop land
(B) Physical design limitations of the planting unit which prevent it from delivering standard cereal wheat seeds
(C) Environmental protection policies that make using the machine illegal in most regions of South Asia
(D) High upfront purchasing costs combined with the requirement of utilizing a higher horsepower tractor (>50 HP)

2019

167. Land Capability Class I land has:
(A) Highly severe soil erosion hazards and steep topographic gradients
(B) Extremely few physical limitations restricting intensive agricultural use
(C) Frequent seasonal flooding problems that destroy root zone respiration
(D) Very shallow effective rooting depth restricted by dense lithic bedrock

2021

168. The primary driver for the formation of coastal saline wastelands is:
(A) Excessive inland canal irrigation leading to high rising water tables
(B) Continuous heavy applications of synthetic inorganic nitrogen fertilizers
(C) Marine water intrusion triggered by over-extracting coastal aquifers
(D) Widespread deforestation and clear-cutting within remote alpine basins

2017

169. What is a key restorative model for degrading Jhum cultivation areas in the Northeast Himalayas?
(A) Engineering continuous concrete slope barriers to physically stop water runoff and erosion
(B) Implementing strict ecological conservation laws that ban all forms of human habitation
(C) Replacing traditional farming entirely with highly intensive, tractor-drawn tillage systems
(D) Integrating Alnus nepalensis trees into fallow cycles to speed up soil nitrogen fixation

NODIA

2010

170. Which classification categorizes agroforestry systems based on their environmental adaptation (e.g., arid, tropical)?
(A) Ecological classification
(B) Structural classification
(C) Socio-economic classification
(D) Functional classification

high initial capital investment costs and a lack of well-developed custom hiring networks in many intensive agricultural regions.

10. (B) I and III
The Land Capability Classification system categorizes land based on agricultural suitability and limitations. Classes I through IV are suitable for cultivation with progressive conservation needs, while Classes V through VIII are unsuitable for cultivation. Limitations and hazards increase progressively from Class I to Class VIII, making Class VIII land suitable only for recreation or wildlife.

11. (B) Unscientific water management and intense surface runoff
Gullied and ravinous lands are extreme forms of water erosion that degrade vast agricultural tracts. This process is driven primarily by intense surface runoff during heavy rainfall events combined with unscientific water and soil management practices. Over time, concentrated water flow carves deep channels, dissecting the landscape and forming barren wastelands.

12. (B) Cropping phase utilizing soil fertility
Traditional shifting cultivation, or Jhum, involves a cyclical sequence of ecological and agricultural phases. After slashing and burning the native forest vegetation, farmers utilize the nutrient-rich ash layer as a natural fertilizer. This directly initiates the cropping phase, during which diverse food crops are cultivated until the soil fertility is depleted.

13. (A) Integration of trees, crops, and pasture/ animals
Agrosilvopastoral systems are specialized land-use designs categorized under agroforestry. These systems are structurally defined by the deliberate and planned integration of woody perennials, agricultural crops, and pastures or livestock on the same land management unit. This combination optimizes spatial and temporal resource utilization while providing diversified ecological and economic outputs.

14. (C) Excretion of phytotoxic phenolics inhibiting germination
Allelopathy in agroforestry systems involves the chemical interaction between different plant species. A negative complementary effect occurs when trees release harmful biochemical compounds, such as phytotoxic phenolics, into the surrounding soil. These allelochemicals directly inhibit the germination, growth, and development of companion agricultural crops, thereby reducing overall system productivity.

15. (A) Both A and R are true and R is the correct explanation of A.
Grasses adapted to heavy grazing utilize specific physiological and morphological strategies to survive defoliation. Their decumbent growth habits place the active growing points very close to the soil surface. Because these growing points are located in the basal meristems, they are physically protected from removal by grazing herbivores, allowing rapid post-grazing regrowth.

16. (C) Peninsular India including the Deccan Plateau
The Sehima-Dichanthium grassland cover is one of the major ecological grass covers identified across India. This specific grassland type is primarily distributed throughout the peninsular region, including the Deccan Plateau. It thrives on red and black clay soils under semi-arid conditions, supporting diverse local livestock populations through seasonal forage production.

17. (B) Usable forage production and daily animal dry matter needs
Calculating the carrying capacity of a rangeland requires quantifying the balance between forage supply and animal demand. The essential parameters needed for this calculation include the total usable annual forage production of the pasture and the daily dry matter requirements of the specific animal units grazing the land, ensuring long-term ecological sustainability.

18. (D) Microbial immobilization of available soil nitrogen
Incorporating organic residues with high carbon-to-nitrogen ratios, such as wheat straw, stimulates intense soil microbial activity. To decompose this abundant carbon source, microbes require more nitrogen than the residue contains. Consequently, they scavenge available inorganic nitrogen from the soil solution, leading to temporary microbial immobilization and potential crop nitrogen deficiency.

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color is most visually appealing to local operators
(C) Recommending the precise rate, timing, and spatial location for applying chemical inputs
(D) Detailing manual techniques for field laborers to harvest commodity grain crops by hand

2016

181. A system's ecological footprint analysis evaluates:
(A) Biologically productive land and water needed to sustain a specific agricultural system
(B) Direct mechanical compaction depths caused by heavy tractor tire passes over wet clay soil
(C) Total organic carbon stocks located exclusively within the upper five centimeters of topsoil
(D) Cumulative leaf surface area and spatial distribution patterns across a single mature crop canopy

2019

182. A fundamental shift from conventional to Conservation Agriculture (CA) alters soil hydrology primarily by:
(A) Severely disrupting vertical macro-pore pathways and internal drainage
(B) Accelerating surface physical crust formation and clay dispersion processes
(C) Completely halting the downward movement of deep groundwater recharge
(D) Enhancing soil water infiltration while reducing surface runoff velocity

2018

183. Greenhouse gas emissions from flooded rice cultivation can be mitigated most effectively by:
(A) Increasing continuous flooding duration
(B) Implementing Alternate Wetting and Drying (AWD)
(C) Applying extremely high doses of raw farmyard manure
(D) Deep plowing while flooded

2010

184. Under strict Conservation Agriculture (CA) systems, what happens to applied phosphorus fertilizer over multiple seasons?
(A) It leaches rapidly down to the active root zone through macropore flow
(B) It undergoes biological reduction and is completely lost into the air as a gas
(C) It accumulates primarily in the shallow upper zero to five centimeter soil layer
(D) It is mixed uniformly down to thirty centimeters of soil depth by microfauna

2021

185. Match the AI concept (List I) with its agronomic application (List II):
List I: (AI Concept)
P. Internet of Things (IoT)
Q. Convolutional Neural Networks (CNN)
R. Predictive Analytics
S. Autonomous Robotics
List II: (Agronomic Application)
1. Real-time soil moisture and climate sensor networks
2. Automated laser weeding and precision harvesting
3. Yield forecasting based on historical and current weather data
4. Identification of leaf spot diseases from smartphone photos
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-1, R-2, S-3
(C) P-1, Q-3, R-4, S-2
(D) P-3, Q-2, R-1, S-4

2021

186. Weed dynamics in zero-tillage often show a decline in Phalaris minor in wheat because:
(A) Lack of tillage avoids bringing buried seeds up to shallow depths optimal for germination
(B) Surface residue decomposition releases complex phytotoxins that are highly lethal to wheat
(C) Seeds are obligate hydrophytes that strictly require deep, flooded fields to germinate
(D) Weed populations undergo rapid genetic mutations, losing all reproductive viability

2005

187. The survival of soil-borne pathogens under Conservation Agriculture (CA) is heavily dependent on:
(A) Direct exposure to high UV radiation on the soil surface
(B) The rate of decomposition of the infected crop residue substrate
(C) Ambient air velocity and wind patterns over bare soil fields
(D) Annual physical inversion of soil horizons during deep plowing

2019

188. Which machinery is specifically designed to seed directly into heavy, loose crop residue without prior tillage or burning?

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this water available to plant roots against the downward pull of gravity.

29. (A) Land and water area needed for resources and waste assimilation
Ecological footprinting is a sustainability metric that assesses human demand on natural ecosystems. In agriculture, it measures the total productive land and water area required to produce all the resources consumed by a system, as well as the area needed to assimilate the waste generated by those agricultural activities under prevailing technologies.

30. (D) IV
Shifting cultivation is known by various regional names worldwide. In India, it is called Jhum in the Northeast, Podu in Andhra Pradesh and Odisha, and Bewar in Madhya Pradesh, while Milpa is the term used in Central America. Ponam is practiced in Kerala, making the combination associating it with Rajasthan incorrect.

31. (D) Land undeveloped for vegetation due to extreme physical limits
An unculturable wasteland refers to land that cannot be brought under cultivation or vegetative cover due to severe, permanent physical limitations. Examples include barren rocky areas, steep snow-covered mountain peaks, and hyper-arid deserts. These lands are economically unreclaimable for agricultural production or biological development due to extreme environmental constraints.

32. (C) Deep tree roots recycling nutrients leaching below the crop root zone
In agroforestry, the safety-net role describes a key below-ground mechanism for nutrient conservation. Deep-rooted tree species act as a physical filter, intercepting and absorbing highly mobile plant nutrients, such as nitrates, that have leached past the shallower root zone of annual agricultural crops. This process recycles nutrients back to the surface soil.

33. (B) Arid and semi-arid regions
The Dichanthium-Cenchrus-Lasiurus grass cover is a highly resilient native ecological grassland type in India. This specific vegetative cover is primarily adapted to the arid and semi-arid regions, particularly in northwest India and western Rajasthan. These grass species possess deep root systems and drought-resistant physiological traits suited for low-rainfall environments.

34. (D) Proliferation of woody shrubs and unpalatable forbs
Severe overgrazing disrupts the ecological balance of rangelands. As livestock repeatedly consume highly palatable perennial grass species, these plants lose vigor and die out. This reduction in competition allows unpalatable weeds, woody shrubs, and toxic forbs to proliferate, which serves as a primary indicator of rangeland degradation and retrogressive plant succession.

35. (A) White-rot fungi
Lignin is a highly complex, recalcitrant structural polymer found in agricultural plant residues. Its decomposition is a slow process that requires specialized enzymatic machinery. White-rot fungi are the primary microbial group capable of degrading lignin efficiently, utilizing extracellular enzymes like lignin peroxidases, manganese peroxidases, and laccases to break open the aromatic rings.

36. (C) Pyrolysis under low or zero oxygen conditions
While conventional composting is a biological process driven by aerobic microorganisms under moist, warm conditions, biochar production is a thermochemical process. It fundamentally relies on pyrolysis, which involves heating biomass to high temperatures under highly restricted or zero oxygen conditions, yielding a stable, carbon-rich product that resists rapid microbial decomposition.

37. (A) Phenolic acids
Allelochemicals are secondary plant metabolites released into the environment that influence the growth of neighboring species. Phenolic acids represent a major, widespread biochemical class of these active agents. They are synthesized via the shikimic acid pathway and can inhibit key physiological processes in target weeds, including seed germination, cell division, and nutrient uptake.

38. (D) Sensor data transmitted to decision-support algorithms
An Internet of Things architecture in automated irrigation systems integrates real-time environmental monitoring with automated control. It relies on transmitting continuous data from field-deployed soil moisture, temperature,

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(A) Provide a massive immediate dose of highly soluble inorganic nitrogen to crops
(B) Act as a systemic, selective pre-emergence chemical herbicide in wet fields
(C) Drastically and rapidly acidify highly calcareous soils in semi-arid zones
(D) Persist for centuries, improving carbon storage and retaining soil water

2003

199. Allelopathic chemicals belonging to the phenolic acid class are typically released into the soil via:
(A) Direct mechanical contact between adjacent herbaceous stems
(B) Root exudation and leaching from decomposing leaf residues
(C) Atmospheric ionization generated by local lightning strikes
(D) Wind-borne transport of specific vegetative pollen vectors

2024

200. Energy plantations utilize Short-Rotation Intensive Culture (SRIC) primarily to generate feedstock for:
(A) Processing into high-end lumber for residential and industrial construction
(B) Manufacturing highly nutritious plant products for direct human consumption
(C) Thermochemical conversion to generate usable off-grid electricity or heat
(D) Extracting secondary medicinal compounds and volatile plant essential oils

2015

201. Which component is the fundamental building block of an Artificial Neural Network used in agronomic modeling?
(A) The physical tractor power take-off shaft
(B) The relational database query structure
(C) The computerized drone propulsion system
(D) The basic artificial neural perceptron

2022

202. Real-time crop health monitoring using AI often relies on calculating the NDVI. What does NDVI stand for?
(A) Normalized Difference Vegetation Index
(B) Natural Diverse Vegetation Indicator
(C) Negative Data Variance Analytical Input
(D) Neutral Density Visual Spectrum Image

2007

203. Which aspect is a fundamental socio-economic pillar of sustainable agriculture?
(A) Maximizing chemical input application rates to guarantee short-term yield spikes
(B) Ensuring economic viability while maintaining equitable resource distribution pathways
(C) Establishing complete systemic reliance on fossil-fuel based non-renewable energy
(D) Prioritizing corporate market monopolies over regional food security initiatives

2017

204. The System Sustainability Index (SSI) is considered superior to simple yield data because it:
(A) Focuses exclusively on the absolute maximum theoretical crop yield potentials
(B) Integrates ecological, economic, and social performance indicators over time
(C) Intentionally ignores structural soil quality dynamics and biological activity
(D) Is significantly simpler to calculate mathematically without collecting field data

2025

205. Which consequence is directly associated with the continued practice of conventional intensive tillage?
(A) Degradation of soil structure and accelerated oxidative loss of organic matter
(B) Rapid, steady accumulation of organic carbon compounds within the root zones
(C) Enhanced water-holding capacity and increased pore continuity across the profile
(D) Complete elimination of annual weed species through deep mechanical weed seed burial

2017

206. Soil carbon sequestration strategies in agriculture aim to achieve a "net negative" greenhouse gas profile by:
(A) Deep geological injection of highly pressurized liquefied carbon dioxide gas
(B) Direct thermal combustion of field crop residues under high oxygen conditions
(C) Storing more carbon in the soil pool than is emitted by general farming activity
(D) Wrapping field surfaces in dense synthetic plastic sheets to stop gas diffusion

2025

207. Which fertilizer application method is specifically adapted for nitrogen management in heavy-residue zero-tillage systems?
(A) Uniform surface broadcasting of dry granular urea
(B) Aerial dusting of liquid fertilizers from

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planes
(C) Flooding fields with raw gaseous anhydrous ammonia
(D) Sub-surface banding using coulter-equipped drills

2002

208. How does the presence of a surface crop residue mulch affect soil temperature dynamics?
(A) It increases diurnal temperature fluctuations throughout the year
(B) It lowers soil temperature in summer and buffers against extreme cold in winter
(C) It causes the soil to remain permanently frozen in temperate zones
(D) It has zero effect on soil thermal conductivity or heat capacity

2002

209. In contrast to conservation agriculture, how are weed seeds distributed within the soil profile under conventional tillage?
(A) Concentrated exclusively in the lower subsoil below 50 cm
(B) Distributed relatively uniformly throughout the active plow layer (typically 0 to 15 or 20 cm)
(C) Confined entirely to the top 0 to 2 cm of the soil surface
(D) Completely destroyed due to the mechanical action of the plow

NODIA

2013

210. Which statement most accurately describes the epidemiological impact of Conservation Agriculture (CA) on plant diseases?
(A) It results in the total elimination and universal eradication of all crops diseases across regions
(B) Pathogens residing in the soil cannot complete their survival cycles without continuous deep tillage
(C) Plant viral diseases display rapid exponential increases when thick organic residues cover fields
(D) Foliar pathogens decline, while residue-borne pathogens may increase absent proper crop rotations

****

ANSWERS

1. (B) Technological singularity
Sustainable agriculture is fundamentally built upon three key foundational pillars, which include environmental health, economic profitability, and social equity. While advanced modern technologies support agricultural production, technological singularity represents a hypothetical future point of uncontrollable technological growth and is not recognized as a primary pillar or dimension of sustainable farming systems.

2. (D) Linear combinations of weighted soil indicators
Computing the Soil Quality Index typically involves selecting key soil indicators, scoring them, and combining them mathematically. This integration is most commonly achieved using linear combinations of weighted soil indicators, where each parameter is assigned a specific weight based on its relative importance in maintaining essential soil ecological, physical, and chemical functions.

3. (A) Maintenance of a permanent or semi-permanent organic soil cover
Conservation Agriculture relies on three interlinked core operational principles. These principles encompass minimizing mechanical soil disturbance through zero tillage, maintaining a permanent or semi-permanent organic soil cover with crop residues, and implementing diversified crop rotations. This sustainable system enhances soil biological activity, prevents severe erosion, and optimizes moisture conservation.

4. (C) Continuous flooding in lowland rice cultivation
Continuous flooding in lowland rice fields creates highly anaerobic soil conditions. These oxygen-depleted environments favor the proliferation of methanogenic archaea, which decompose organic matter and generate substantial biogenic methane. This specific flooded field management practice is recognized as a major global source of anthropogenic greenhouse gases within the agricultural sector.

5. (A) Stratification of immobile nutrients near the soil surface
Under long-term zero-tillage systems, the absence of soil inversion results in the accumulation of crop residues and applied fertilizers on the soil surface. Consequently, relatively immobile nutrients like phosphorus and potassium remain concentrated in the upper soil layer, creating a distinct vertical gradient known as nutrient stratification.

6. (D) By reducing raindrop impact energy and surface soil evaporation
Retaining crop residue on the soil surface acts as a physical barrier. This protective layer absorbs the kinetic energy of falling raindrops, which prevents soil crusting and maintains high infiltration rates. Additionally, the residue shades the soil surface, reducing solar radiation intercept and significantly decreasing soil water loss through evaporation.

7. (B) Increased dominance of surface-germinating annual grass weeds
In Conservation Agriculture systems, the absence of tillage leaves the vast majority of weed seeds on or near the soil surface. This lack of soil inversion suppresses deep-buried seeds but favors species adapted to surface germination, leading to an increased dominance of small-seeded, surface-germinating annual grass weeds over time.

8. (C) Debris-borne necrotrophic fungal pathogens
Leaving crop residues on the soil surface creates a moist, sheltered microclimate that provides a survival substrate for pathogens. This retention particularly benefits debris-borne necrotrophic fungal pathogens, which overwinter on crop residues and initiate early infections in subsequent seasons, requiring diversified crop rotations and integrated pest management strategies.

9. (D) High initial machinery cost and limited custom hiring access
The Happy Seeder is highly effective for direct drilling of wheat into heavy standing rice residues. However, its widespread adoption by smallholder farmers is severely constrained by socio-economic factors. These limitations include

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2018
171. In agroforestry, "allelopathic interference" is most likely to cause:
(A) Highly enhanced seed germination and accelerated initial vegetative growth rates
(B) Reduced growth and germination of understory crops caused by released phytotoxins
(C) Measurable increases in soil profile moisture retention and water-use efficiency
(D) Improved soil physical aggregate stability and overall organic matter persistence

2012
172. The term "agrostology" refers specifically to the scientific study of:
(A) Agricultural economics
(B) True grasses (Gramineae/Poaceae)
(C) Soil microorganisms
(D) Tree canopy architecture

2025
173. The major ecological cover of grass in the high altitudes of the Himalayas is characterized by species such as:
(A) Danthonia and Phleum species
(B) Dichanthium annulatum
(C) Chrysopogon fulvus
(D) Spinifex littoreus

2008
174. Which system involves grazing a pasture and then physically moving the livestock to a new area, allowing the first area time to regrow?
(A) Continuous grazing
(B) Zero grazing
(C) Rotational grazing
(D) Deferred grazing

2003
175. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R):
Assertion (A): Cereal residues typically have a higher C:N ratio than leguminous residues.
Reason (R): Microbes decomposing cereal residues will generally release (mineralize) nitrogen immediately into the soil solution.
In light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014
176. Which condition is essential for optimal anaerobic composting?
(A) Promoting continuous mechanical turning of organic substrates
(B) Restricting internal moisture contents to levels below 10%
(C) Maintaining a completely oxygen-free environment in a vessel
(D) Exposing surface layers to highly concentrated solar UV light

2022
177. Which of the following is a classic example of crop-crop allelopathy where the residues of a preceding crop inhibit the growth of a subsequent crop?
(A) Wheat residues inhibiting wild oat growth in a subsequent season
(B) Sunflower residues inhibiting the growth of subsequent crops like mustard or linseed
(C) Alfalfa promoting the growth of subsequent corn crops through nitrogen contribution
(D) Marigold promoting tomato growth by attracting beneficial predatory insects

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2004
178. What is the typical rotation period (harvest cycle) for species grown under Short-Rotation Intensive Culture (SRIC) for bioenergy?
(A) 1 to 2 months
(B) 2 to 10 years
(C) 15 to 25 years
(D) 50 to 80 years

2014
179. In AI, "Computer Vision" relies heavily on which underlying technological framework to analyze crop images?
(A) Deep Learning utilizing multi-layered Convolutional Neural Networks
(B) Natural Language Processing parsing text-based crop diagnostic inputs
(C) Simple linear programming matrices optimizing seasonal harvest schedules
(D) Basic spreadsheet macros automating regional statistical calculation tasks

2016
180. Precision farming utilizes AI decision support systems primarily to answer which operational question?
(A) Estimating what the absolute national gross domestic product value will be in the next year
(B) Determining which specific tractor paint

19. (A) Rapid microbial breakdown of easily metabolizable carbon
The active thermophilic phase of aerobic composting is characterized by high temperatures, usually between fifty-five and sixty-five degrees Celsius. This heat is generated by the rapid biochemical breakdown of easily metabolizable carbon compounds, such as sugars, starches, and proteins, by heat-tolerant thermophilic bacteria and actinomycetes, driving rapid volume reduction.

20. (B) I, III and IV
Allelopathy involves chemical interactions where plants release biochemical compounds that influence neighboring vegetation. Terpenoids and phenolics are major classes of these allelochemicals. They are released through volatilization in arid environments, root exudation, leaching, or residue decay. Juglone from black walnut is a classic example of a highly potent, naturally occurring allelochemical.

21. (A) Populus deltoides (Poplar)
Short-Rotation Intensive Culture systems utilize fast-growing woody species to maximize biomass yield for bioenergy and pulp production. Populus deltoides, commonly known as poplar, is highly suited for this purpose due to its high photosynthetic efficiency, rapid early growth rates, ease of vegetative propagation, and positive response to high planting densities.

22. (D) Processing and classifying spatial crop health images
Convolutional Neural Networks are advanced deep learning models highly specialized for processing grid-structured data. In precision agriculture, their primary function is to analyze and classify spatial imagery acquired from satellites, drones, or ground-based cameras, enabling automated crop health monitoring, disease detection, and precise weed identification across diverse field environments.

23. (B) It provides high spatial and temporal resolution multispectral imagery
Using unmanned aerial vehicles, or drones, for agricultural mapping offers significant advantages over satellite remote sensing. Drones deliver high spatial and temporal resolution multispectral imagery, allowing farmers to identify localized crop stress, nutrient deficiencies, or pest infestations in real time, which facilitates rapid, targeted, and highly precise field-level management interventions.

24. (C) The system is highly unsustainable and degrading rapidly
The System Sustainability Index is a quantitative metric used to evaluate the long-term ecological, economic, and social performance of agricultural systems. An index value approaching zero indicates that the system is highly unsustainable, experiencing severe resource degradation, and failing to maintain stable productivity levels, necessitating immediate corrective management interventions.

25. (B) P-3, Q-1, R-4, S-2
Various specialized implements are key to Conservation Agriculture. The zero-till drill sows seeds directly without prior tillage, while the Happy Seeder sows wheat directly through standing paddy residues by shredding and mulching them. The Turbo Seeder manages heavy loose residue during sowing, and the laser land leveler ensures high-precision field grading.

26. (A) Global Warming Potential (GWP)
Evaluating the climate impact of agricultural practices requires aggregating the emissions of various greenhouse gases. Global Warming Potential is the primary metric used for this purpose, as it converts emissions of gases like methane and nitrous oxide into carbon dioxide equivalents over a standardized one-hundred-year horizon, reflecting their cumulative radiative forcing.

27. (B) Volatilization of ammonia from surface residues
Broadcasting urea fertilizer onto the surface of conservation tillage fields often leads to high nitrogen losses. This occurs because the abundant urease enzymes in crop residues rapidly hydrolyze urea into ammonia gas. Deep placement of nitrogen fertilizer bypasses this residue layer, keeping the nutrient in contact with soil particles to minimize ammonia volatilization.

28. (B) Capillarity driven by matric potential
After gravitational water drains from a saturated soil, the remaining water is held within the soil matrix. This retention is primarily driven by capillarity, which is governed by matric potential. Adhesion and cohesion forces hold water molecules inside small soil pores, making

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(A) Moldboard plow
(B) Happy Seeder
(C) Cultivator
(D) Spike-tooth harrow

2012

189. Which class of land in the Land Capability Classification (LCC) system is characterized by severe limitations that make it generally unsuited for cultivation and restrict its use largely to pasture, range, woodland, or wildlife food and cover?
(A) Class I
(B) Class II
(C) Class III
(D) Class VI

2022

190. Unculturable wastelands, as mapped by the National Remote Sensing Centre (NRSC), primarily include:
(A) Heavily degraded communal pasture lands with zero vegetative yield
(B) Arable crop lands left completely uncropped for more than one year
(C) Barren rocky areas, snow-covered peaks, and steep glaciated regions
(D) Intensively cultivated saline-alkaline soils across alluvial plains

2017

191. The traditional Shifting Cultivation cycle (Jhum) is considered unsustainable today primarily because:
(A) Manual slash and burn field preparation techniques cannot physically be completed by modern human labor
(B) Mineralized ash residue deposited on the surface is highly toxic to the germination of most cash crops
(C) The modern crop genotypes used require continuous high-dose applications of synthetic inorganic fertilizers
(D) High population density has severely compressed fallow periods, stopping natural soil nutrient recovery

2024

192. Which agroforestry system is structurally defined as combining agricultural crops with woody perennials?
(A) Silvopastoral
(B) Agrosilvopastoral
(C) Agrisilvicultural
(D) Aquaculture

2017

193. The primary reason for root pruning of trees in an agrisilvicultural system is to:
(A) Accelerate canopy development and increase annual tree fruit production
(B) Minimize underground crop-tree competition for water and soil nutrients
(C) Stimulate localized roots to release defensive allelopathic chemicals
(D) Inhibit vegetative shoots to prevent the tree from growing normal leaves

2022

194. Agrostology focuses heavily on understanding grass tillering, which is controlled largely by:
(A) Nitrogen fixation in the root nodules
(B) Allelopathic suppression from companion weeds
(C) The color of the incident light exclusively
(D) Apical dominance mediated by auxins

2003

195. Which grass species is best adapted to the arid desert regions of Rajasthan?
(A) Cenchrus ciliaris
(B) Imperata cylindrica
(C) Themeda anathera
(D) Phragmites karka

NODIA

2024

196. Carrying capacity of a rangeland is a dynamic metric that fluctuates primarily based on:
(A) Genetic traits and body size variations of the specific grazing livestock
(B) Geographic distances from the rangeland boundary to major urban markets
(C) Inter-annual rainfall variation and its direct impact on forage production
(D) Structural strength and overall density of the perimeter fencing materials

2008

197. Agro-industrial residues with high cellulose content but low lignin decompose:
(A) Rapidly, because cellulose is easily broken down by microbial cellulase enzymes
(B) Slowly, because crystalline cellulose fractions remain completely chemical inert
(C) Only when temperatures reach extreme thermophilic environments exceeding 100°C
(D) Only when the surrounding composting matrix contains zero bioavailable nitrogen

2011

198. The most significant agronomic benefit of incorporating biochar into soil is its ability to:

and weather sensors to centralized cloud-based decision-support algorithms. These algorithms process the inputs and automatically trigger irrigation valves to optimize crop water-use efficiency.

39. (B) Soluble protein and amino acid fractions
Analyzing the energy value of agro-industrial residues involves evaluating parameters that influence thermal properties. While moisture and ash content dictate physical combustion quality, the presence of specific biochemical fractions like proteins and amino acids introduces high nitrogen levels, which can lead to increased nitrogen oxide emissions and lower overall combustion efficiency.

40. (B) Slashing, Burning, Cropping, Fallow
Traditional shifting cultivation, also known as slash-and-burn agriculture, follows a strict chronological sequence of land management phases. The process begins with slashing the standing forest vegetation, followed by burning the dried plant debris to release nutrients. Farmers then initiate the cropping phase, and finally leave the plot fallow for natural vegetative regeneration.

41. (D) Net economic returns and benefit-cost ratios
Evaluating the sustainability of any agricultural system requires assessing its long-term financial viability. Net economic returns and benefit-cost ratios are key parameters used to directly measure the economic dimension. A system must remain profitable for farmers, ensuring that financial gains consistently outweigh operational costs while buffering against market volatility and production risks.

42. (A) Rapid mineralization of protected organic carbon pools
Conventional tillage physically breaks down soil macroaggregates, which exposes organic carbon that was previously protected within these structures to microbial decomposition. This sudden exposure increases microbial respiration rates, leading to the rapid mineralization of active soil organic carbon pools and a subsequent decline in overall soil organic matter content over time.

43. (B) Net transfer of CO_2 into long-lived soil organic pools
Soil carbon sequestration is a critical process for mitigating climate change through agricultural management. It is defined as the net transfer of atmospheric carbon dioxide into secure, long-lived soil organic pools. This is achieved by increasing plant biomass inputs and minimizing soil disturbance to enhance the long-term stabilization of carbon within stable soil aggregates.

44. (B) It promotes fine root proliferation near the soil surface
In zero-tillage systems, the concentration of immobile nutrients like phosphorus and potassium near the soil surface alters root architecture. Crop roots adapt plastically to this nutrient stratification by promoting the proliferation of highly branched fine roots in the topsoil layer, where nutrient and moisture availability from crop residues is highest.

45. (A) 1, 4, 3, 2
Different organic materials exhibit distinct carbon-to-nitrogen ratios based on their biochemistry. Alfalfa hay has the lowest ratio, followed by rotted farmyard manure, which has undergone stabilization. Wheat straw is higher due to its structural cellulose, while sawdust has the highest ratio, often exceeding several hundred to one, due to its high lignin content.

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46. (C) Darcy's Law under matric and gravity gradients
Water movement in unsaturated soils is governed by fundamental physical principles. It is mathematically described by Darcy's Law, as modified for unsaturated conditions, where water flow is driven by gradients in both matric potential and gravity. The presence of crop residue influences these gradients by maintaining surface soil moisture and preventing rapid drying.

47. (D) Perennial weeds like Cyperus rotundus decrease under zero-tillage.
Weed dynamics change significantly when transitioning to Conservation Agriculture. While the lack of tillage concentrates weed seeds near the surface and can suppress certain annuals like Phalaris minor over time, it often leads to an increase, rather than a decrease, in hard-to-control perennial weeds like Cyperus rotundus, which propagate via underground tubers.

48. (C) Residues intercept soil herbicides, lowering surface concentration
In Conservation Agriculture systems, the presence of a thick surface residue layer can interfere with chemical weed control. The residues physically intercept pre-emergence herbicides, preventing a significant portion of the active ingredient from reaching the soil surface. This reduces the effective concentration of the herbicide in the weed germination zone, potentially lowering control efficacy.

49. (B) Entomopathogenic fungi and beneficial ground beetles
Retaining crop residues on the soil surface moderates soil temperature fluctuations and conserves moisture. This altered microclimate creates a highly favorable habitat that promotes beneficial biological agents. These include entomopathogenic fungi, which control insect pests, and predatory ground beetles, which feed on weed seeds and pest larvae, enhancing biological pest control in the system.

50. (B) II
Modern Conservation Agriculture relies on specialized machinery for seeding through heavy residues. While the Turbo Seeder does not require complete residue removal, the Happy Seeder is specifically engineered to manage loose straw by flailing it, sowing the seed, and blowing the residue back behind the seeding tines as a protective surface mulch.

51. (A) Pasture, woodland, or wildlife food/cover
Under the Land Capability Classification system, Class VI lands have severe physical limitations that make them entirely unsuitable for regular cultivation. These limitations may include steep slopes, severe erosion hazards, or shallow soils. Consequently, these lands are best suited for permanent vegetative cover, including pastures, forestry, woodlands, or wildlife habitats.

52. (C) Over-irrigation leading to waterlogging and salinity
In many large-scale irrigated command areas, poor water management practices have degraded productive lands into culturable wastelands. Over-irrigation and inadequate drainage systems cause water tables to rise near the surface, leading to waterlogging. As this water evaporates, it leaves behind dissolved salts, resulting in soil salinization that restricts crop growth.

53. (A) Replacing natural fallows with nitrogen-fixing tree species
Traditional shifting cultivation, or Jhum, has become unsustainable due to shortened fallow cycles. Restorative models for these degraded lands focus on accelerating soil fertility recovery. This is achieved by replacing natural fallows with nitrogen-fixing tree species, which rapidly accumulate biomass, capture atmospheric nitrogen, and stabilize fragile sloping soils during the fallow period.

54. (D) Livestock or pasture for grazing
Agroforestry systems are classified based on their structural components. An agrisilvicultural system is specifically defined by the integration of agricultural crops and woody perennials, such as trees or shrubs, on the same land unit. Because this system is limited to crops and trees, it strictly excludes livestock or pastures meant for animal grazing.

55. (A) Both A and R are true and R is the correct explanation of A.
Root pruning is an important management practice in intensive agroforestry systems. By physically cutting the lateral roots of trees near the crop rows, farmers restrict tree roots to deeper soil horizons. This spatial separation minimizes below-ground competition for water and nutrients between trees and shallow-rooted crops, allowing both to coexist productively.

56. (C) Intercalary meristems at the leaf and internode bases
Grasses possess unique morphological adaptations that make them highly resilient to grazing and mowing. Unlike dicots, which have apical meristems at the tips of their stems, grasses feature active intercalary meristems located at the bases of their leaves and internodes. This allows them to quickly regrow lost tissue after defoliation.

57. (D) Wet, marshy, or low-lying waterlogged areas
The Phragmites-Saccharum-Imperata grass cover is a distinct ecological association identified in India's grassland classifications. These grass species are highly adapted to excessive moisture conditions. They are typically found in wet, marshy, or low-lying waterlogged areas, such as river floodplains, deltaic regions, and poorly drained lowlands across the country.

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58. (A) Delaying grazing on an area until key forage species have set seed
Deferred grazing is a specialized rangeland management strategy aimed at maintaining pasture productivity. It involves delaying livestock grazing on a specific pasture area until the key, highly palatable forage grass species have completed their reproductive cycle and set seed. This practice ensures natural seed dissemination and strengthens plant root reserves.

59. (B) The lignin to nitrogen ratio of the residue
The rate at which agricultural residues decompose in the soil is regulated by their chemical composition. The lignin-to-nitrogen ratio serves as a key biochemical predictor of these decomposition kinetics. Residues with a high ratio decompose slowly because lignin is highly resistant to microbial breakdown, and low nitrogen levels limit microbial population growth.

60. (B) II and IV
Organic residue recycling practices are governed by biological constraints. While vermicomposting uses specialized earthworms like Eisenia fetida, aerobic composting generates higher temperatures than anaerobic processes. To support rapid microbial activity, aerobic composting piles require maintaining a moisture level of fifty to sixty percent, making options suggesting ten percent or higher anaerobic temperatures incorrect.

61. (A) Direct release of toxic chemicals from a living plant to the environment
In crop-weed ecology, true allelopathy refers to the direct release of active phytotoxic chemical compounds from a living plant into the surrounding environment. These secondary metabolites are excreted through root exudates, volatilization from leaves, or foliar leaching, directly inhibiting the germination, growth, or physiological development of adjacent competing weed or crop species.

62. (C) Mean Annual Increment (MAI) of woody biomass
Evaluating the productivity of short-rotation forestry and energy plantations requires measuring wood accumulation over time. The primary metric used for this purpose is the Mean Annual Increment. This parameter represents the average growth of woody biomass per hectare per year over the rotation period, helping foresters determine the optimal harvesting cycle.

63. (D) By identifying weed species or pest damage from images
Computer vision technology has revolutionized precision agriculture by automating visual inspection tasks. By analyzing high-resolution digital images captured by drones, tractors, or smartphones, advanced machine learning models can rapidly identify and distinguish specific weed species from crops, detect early insect pest damage, and diagnose plant diseases, enabling targeted field interventions.

64. (C) Water-use efficiency (WUE) by irrigating exactly at the allowable depletion threshold
Automated irrigation systems leverage Internet of Things technology to optimize field water management. By integrating continuous data from soil moisture sensors, these systems determine the exact moisture status of the root zone. They schedule irrigation events precisely when soil water reaches the allowable depletion threshold, thereby maximizing water-use efficiency and preventing crop stress.

65. (A) P-4, Q-1, R-2, S-3
Agroforestry systems are classified using diverse criteria. The structural basis categorizes systems by the spatial and temporal arrangement of components, while the functional basis focuses on their protective or productive roles. The socio-economic basis considers the scale of production, and the ecological basis classifies them according to adaptation to specific climatic zones.

66. (D) Heavy reliance on carbon-intensive synthetic inputs
An agricultural product's ecological footprint reflects the total environmental pressure exerted during its production. This footprint is most negatively impacted by a heavy reliance on carbon-intensive synthetic inputs, such as chemical nitrogen fertilizers and chemical pesticides. These inputs require substantial fossil fuel energy for manufacturing, transportation, and field application, increasing greenhouse gas emissions.

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67. (A) Enhanced aggregate stability leading to reduced water erosion
Transitioning to Conservation Agriculture provides significant environmental benefits. By

107. (B) Highly porous structure and large surface area, increasing both CEC and water retention
Biochar undergoes pyrolysis, creating an extremely porous physical structure with an exceptionally high specific surface area. This physical framework enhances soil quality by creating numerous exchange sites that boost cation exchange capacity, thereby retaining essential plant nutrients. Additionally, these microscopic pores act as tiny reservoirs that physically trap and hold water, significantly increasing overall soil moisture retention.

108. (B) Sorghum root exudates (sorgoleone) that suppress the growth of certain broadleaf weeds
Sorghum plants synthesize and actively secrete a hydrophobic compound known as sorgoleone from their root hairs into the surrounding rhizosphere. This biological molecule acts as a highly potent natural herbicide that disrupts key physiological processes, including photosynthetic electron transport, in neighboring species. Consequently, this allelochemical effectively suppresses the germination and development of competitive broadleaf weeds in agricultural fields.

109. (A) Fast juvenile growth and ability to coppice
Short-Rotation Intensive Culture systems focus on maximizing biomass production over brief harvesting intervals, typically requiring woody species with exceptional juvenile growth rates. Furthermore, selected trees must possess a strong ability to coppice, which enables them to rapidly regenerate new shoots from the remaining stump after harvesting. This regenerative capacity eliminates the need for replanting after every single harvest.

110. (B) I, II, IV and V
Agricultural Internet of Things networks deploy automated field sensor nodes to continuously monitor key variables, including soil moisture and canopy temperature. These systems utilize edge or cloud computing architectures to process large volumes of environmental data without human intervention. This enables advanced automated applications like smart irrigation systems, while manual human inputs are minimized rather than required.

111. (D) Managing agricultural practices at a highly localized, spatially variable, site-specific level
Precision agriculture focuses on addressing spatial and temporal variability inherent within cultivation fields, rather than treating entire regions uniformly. By utilizing advanced geospatial technologies, global positioning networks, and specialized sensors, this management strategy optimizes the application of resources at a highly localized, site-specific level. This targeted approach significantly improves input efficiency and minimizes environmental degradation.

112. (C) Social equity, household food security, and the well-being of farming communities
Sustainable agriculture relies on three core pillars, which encompass environmental stewardship, economic viability, and social responsibility. The social dimension specifically emphasizes the human element by assessing social equity, labor conditions, and household food security. It evaluates how agricultural practices impact the long-term well-being, health, and cultural resilience of localized rural farming communities and society as a whole.

113. (B) Agronomic yield trends and systematic changes in soil quality indicators over time
The System Sustainability Index is a comprehensive multi-criteria tool designed to monitor the long-term health and viability of agricultural systems. To provide an accurate evaluation, it systematically integrates agronomic productivity, measured via crop yield trends over time, with ecological indicators, such as physical, chemical, and biological soil quality parameters. This combination helps detect early resource degradation.

114. (D) It disrupts soil pores, causing a temporary increase in porosity followed by compaction and crusting
Conventional intensive tillage operations use heavy machinery to physically invert and pulverize the soil profile. While this mechanical action initially increases macroporosity and loosens the surface layer temporarily, it severely disrupts the natural soil structure and pore network. Consequently, the exposed soil aggregates rapidly collapse under rainfall impact, leading to severe surface crusting and subsoil compaction over time.

115. (A) Physical protection of organic matter within stable micro-aggregates
Conservation Agriculture combines zero-tillage with continuous residue retention, which actively promotes the formation of highly stable soil

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77. (A) Silvopastoral system
A silvopastoral system is a specialized agroforestry design. It refers specifically to the deliberate and planned integration of woody trees or shrubs with managed pastures and grazing livestock on the same piece of land. The trees provide shade and shelter for the animals, improve nutrient cycling, and can supply high-quality forage.

78. (C) Species with identical niches will compete to exclusion
The competitive exclusion principle is a fundamental ecological concept. In a mixed tree-crop system, it suggests that two plant species with identical ecological niches cannot coexist stably if resources are limiting. They will compete directly for light, water, and nutrients, eventually leading to the exclusion of the weaker competitor unless niches are differentiated.

79. (D) C_4 pathway and leaf rolling to reduce stomatal conductance
Range grasses in arid and semi-arid environments have developed specialized physiological adaptations to survive severe drought stress. These adaptations include utilizing the highly efficient C_4 photosynthetic pathway, which optimizes water use. Additionally, leaf rolling mechanisms reduce the exposed leaf surface area, decreasing stomatal conductance and limiting water loss through transpiration.

80. (A) Leaching of solubles → Fragmentation by meso-fauna → Chemical alteration by microbes
The decomposition of agricultural residues in the soil follows a distinct chronological sequence. The process begins with the physical leaching of highly soluble organic and inorganic compounds. Next, soil meso-fauna fragment the remaining residues to increase surface area. Finally, microorganisms carry out chemical alteration, breaking down complex polymers into stable humus.

81. (B) Providing pastures rest and recovery periods before regrazing
Rotational grazing is a highly effective rangeland management practice. It improves pasture sustainability primarily by dividing the grazing area into smaller paddocks and rotating livestock through them. This systematic rotation ensures that grazed plants are provided with critical rest and recovery periods, allowing them to rebuild root reserves and vegetative biomass.

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82. (D) Carbon:Nitrogen (C:N) ratio
The carbon-to-nitrogen ratio of organic residues is widely used as a reliable predictor of soil nutrient dynamics. It determines whether soil microbes will release plant-available nitrogen through mineralization or tie it up through immobilization. Residues with a ratio below twenty-to-one favor mineralization, while higher ratios typically trigger nitrogen immobilization.

83. (A) Microorganisms that predigest organic materials
Vermicomposting is a biotechnology that accelerates the stabilization of organic waste. This process relies on a close, synergistic relationship between specialized epigeic earthworms and diverse communities of microorganisms. The microbes predigest the complex organic substrate, making it easier for earthworms to consume and process it into nutrient-rich worm castings.

84. (C) High temperatures and arid conditions
The release of allelochemicals via volatilization is heavily influenced by surrounding weather patterns. High atmospheric temperatures and dry, arid conditions significantly increase the vaporization of volatile organic compounds from plant foliage. Once vaporized, these active biochemical agents disperse through the air, settling onto neighboring soils and inhibiting adjacent plant growth.

85. (A) 2, 1, 3, 4
An automated weed detection system using artificial intelligence follows a logical operational sequence. The process begins with image acquisition using cameras on drones or field rovers. Next, convolutional neural network layers perform feature extraction on these images. This enables output classification into weeds or crops, guiding the targeted application of herbicides.

86. (D) Rapid production of woody biomass for energy or pulp
Short-Rotation Intensive Culture is an agroforestry strategy designed to meet high industrial demands. The primary aim of this system is to maximize the rapid production of woody biomass over short harvest cycles. Fast-growing tree species are planted at high densities and managed intensively to provide feedstock for bioenergy, wood pellets, or paper pulp.

eliminating mechanical tillage and maintaining a protective residue cover, this practice enhances soil organic matter accumulation. This leads to improved soil aggregate stability, which strengthens the soil structure against raindrop impact, increases water infiltration rates, and significantly reduces soil loss from water erosion.

68. (C) Microbial nitrification and denitrification in soils
Agricultural soils are the primary global source of nitrous oxide, a highly potent greenhouse gas. These emissions are predominantly driven by two microbial processes: nitrification, which oxidizes ammonium to nitrate, and denitrification, which reduces nitrate to nitrogen gas under anaerobic conditions. Both pathways produce nitrous oxide as an intermediate byproduct.

69. (A) Banding or injecting nitrogen below the residue
In Conservation Agriculture fields, high surface residue cover contains active urease enzymes that accelerate the conversion of surface-applied urea into volatile ammonia gas. To prevent this nitrogen loss, the most effective application method is banding or injecting nitrogen fertilizers directly below the residue layer, ensuring direct soil contact and rapid nutrient absorption.

70. (A) I, III and V
Soil water dynamics are heavily influenced by management. Retaining crop residue on the surface reduces evaporation and enhances infiltration, which improves overall water-use efficiency. While matric potential is zero in completely saturated soils, water flow under these saturated conditions is dominated by soil macropores, making statements concerning residue blocking pores incorrect.

71. (B) Large-seeded broadleaves to small-seeded annual grasses
Adopting zero tillage alters the vertical distribution of weed seeds in the soil profile. Because the soil is not inverted, weed seeds remain concentrated near the surface. This shift suppresses large-seeded broadleaf species that require deep burial and subsequent tillage-induced cues to germinate, leading to an increased dominance of small-seeded annual grasses.

72. (C) Implementing diverse crop rotations
Retaining crop residues in Conservation Agriculture can harbor debris-borne necrotrophic pathogens. To mitigate this disease risk, implementing diverse crop rotations is highly effective. Rotating crops with non-host species breaks the life cycle of soil-borne pathogens, giving the microbial community time to decompose the infected residues and naturally reduce inoculum levels.

73. (D) Savings in land preparation costs and ensuring timely sowing
Using a zero-till drill to sow wheat directly into harvested rice fields provides substantial economic advantages. This practice eliminates the need for multiple passes of tractor plowing and harrowing, leading to significant savings in fuel and labor costs. Furthermore, it ensures timely sowing of wheat, preventing yield losses associated with planting delays.

74. (B) Class IV
Under the Land Capability Classification system, Class IV lands are characterized by very severe physical limitations. These limitations restrict the choice of crops and require intensive, specialized conservation management practices. Although they are highly susceptible to degradation, these soils are still considered suitable for occasional or highly restricted crop cultivation.

75. (B) Impeded drainage and high water tables
Waterlogged and marshy lands are degraded areas characterized by saturated soil conditions. This category of wasteland is primarily caused by impeded internal soil drainage and high water tables. When excess surface water cannot drain, it fills the soil pore space, creating anaerobic conditions that prevent normal root respiration and restrict vegetative growth.

76. (B) To restore fertility via succession and biomass buildup
In traditional shifting cultivation, the fallow phase is a critical restorative period. The primary ecological objective of this phase is to restore soil fertility. By allowing natural plant succession to occur, wild vegetation builds up significant biomass. This process accumulates essential nutrients in the organic pool and restores soil physical structure.

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fungal pathogens, which survive on the crop debris. This can lead to higher disease pressure in subsequent susceptible crops.

97. (B) Making individual purchase of large CA machinery unviable
The adoption of Conservation Agriculture often requires specialized machinery like zero-till drills and laser land levelers. Fragmented and small land holdings among farmers present a significant socio-economic constraint, as they make the individual purchase of these expensive machines economically unviable, highlighting the need for custom hiring services.

98. (D) Extreme limits making it unsuitable for commercial plants
Under the Land Capability Classification system, Class VIII lands represent the most severely limited land category. These lands are characterized by extreme physical constraints, such as bare rock outcrops, steep slopes, or hyper-arid conditions, which completely prevent their use for commercial plant production, restricting their utility to recreation or wildlife.

99. (A) Multispectral imagery identifying high surface reflectance
Salt-affected lands are a major category of degraded soil and can be mapped effectively using satellite technology. These soils typically exhibit high surface reflectance due to the accumulation of white soluble salts on the surface. Multispectral satellite imagery detects this distinct spectral signature, enabling researchers to map and monitor salinity patterns over time.

100. (C) I and III
Jhum cultivation, or shifting agriculture, is a traditional system facing ecological challenges. While soil degrades during the cropping phase and burning provides a temporary nutrient flush, Jhum is highly unsustainable under short cycles. Furthermore, it does not involve stump removal for tractor plowing, making statements suggesting sustainability under short cycles incorrect.

101. (A) Protein bank
A protein bank is a specialized agroforestry system designed to support livestock production. It involves the deliberate planting and intensive management of fast-growing, nitrogen-fixing woody perennials or shrubs on a specific plot. The primary objective is to harvest their protein-rich leafy fodder to supplement grazing livestock diets, especially during dry seasons.

102. (D) Trees utilize resources that the crop cannot access (e.g., deep soil water)
In agroforestry, the complementary effect represents a positive interaction between tree and crop species. This effect is maximized when trees and agricultural crops exploit different resource niches. For example, deep-rooted trees can access water and nutrients from deep soil horizons that shallow-rooted crop roots cannot reach, minimizing direct resource competition.

103. (B) Tillering from basal axillary buds
Grasses that are highly tolerant to grazing exhibit specific morphological adaptations to survive defoliation. A key feature is the ability to produce new shoots, or tillers, from axillary buds located near the soil surface. This basal tillering allows them to rapidly regenerate vegetative biomass even after heavy grazing has removed their upper leaves.

104. (C) Lasiurus sindicus
Lasiurus sindicus is a highly resilient, perennial grass species native to India. It is a dominant component of the arid and semi-arid grasslands in the Indian desert region, particularly in western Rajasthan. This species is highly adapted to extreme heat and low rainfall, providing critical forage for livestock in desert ecosystems.

105. (A) P-3, Q-1, R-4, S-2
Rangeland management relies on precise ecological terms. Carrying capacity refers to the maximum animal numbers a rangeland can sustainably support, while stocking rate is the actual number of animals grazing an area. Overgrazing is heavy grazing exceeding pasture recovery, and an animal unit is a standard measure based on animal dry matter needs.

106. (A) Lignin content
Lignin is a complex organic polymer that provides structural rigidity to plant cell walls, making them highly resistant to microbial enzymatic breakdown. When the carbon-to-nitrogen ratio remains constant, the concentration of lignin becomes the primary limiting factor because its stable, aromatic structure physically shields more labile components from decomposing organisms, slowing overall residue decay.

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87. (B) Non-linear statistical data tools for yield prediction
In precision agronomy, Artificial Neural Networks are highly valued computational models. They are primarily utilized as advanced, non-linear statistical data tools to predict crop yields, estimate soil moisture, and forecast pest outbreaks. These networks analyze complex, multi-dimensional datasets, including weather patterns, soil properties, and remote sensing imagery, to support decision-making.

88. (C) Substituting synthetic nitrogen with biologically fixed nitrogen
Reducing the ecological footprint of agriculture requires lowering greenhouse gas emissions and energy consumption. A highly effective method is substituting synthetic nitrogen fertilizers with biologically fixed nitrogen from leguminous crops. This substitution reduces reliance on industrial fertilizer manufacturing, which is highly fossil-fuel intensive, thereby lowering the overall carbon footprint.

89. (D) It includes management-sensitive microbial and carbon indicators
It includes management-sensitive microbial and carbon indicators because the Soil Quality Index (SQI) integrates biological, chemical, and physical properties that respond to cultivation practices, organic matter management, and environmental changes. Parameters such as microbial biomass, soil organic carbon, and enzyme activity vary over time, making SQI dynamic. The other options describe relatively static soil characteristics or incorrectly limit the scale and frequency of SQI assessment.

90. (A) I and II
Conservation Agriculture is defined by three fundamental, interlinked principles. These principles are minimizing mechanical soil disturbance through zero tillage, maintaining a permanent or semi-permanent organic soil cover using crop residues, and practicing diversified crop rotations. Because crop diversification is required, strict monocropping contradicts these principles, making options selecting it incorrect.

91. (B) Slight increase or stabilization in surface bulk density
When transitioning a field from conventional tillage to zero-tillage, soil physical properties adjust over time. During the initial transitional years, the absence of mechanical loosening typically leads to a slight increase or stabilization in surface bulk density. However, as organic matter builds up and biopores develop, soil structure eventually improves.

92. (B) Nitrous oxide (N_2O)
Among the major greenhouse gases emitted by agricultural activities, nitrous oxide has an exceptionally high global warming potential. Over a standard one-hundred-year timescale, a single molecule of nitrous oxide is approximately two hundred and ninety-eight times more effective at trapping heat in the atmosphere than a molecule of carbon dioxide.

93. (A) Using drills to band immobile nutrients near seed rows
Because zero-tillage systems concentrate immobile nutrients like phosphorus and potassium near the soil surface, plant root access can be limited. To adapt to this nutrient stratification, farmers must use specialized seed drills to band these fertilizers directly near or below the seed rows, placing the nutrients within the active root zone.

94. (C) Soil pore radius
Capillary rise is a fundamental physical process driving water movement in unsaturated soils. The maximum vertical height to which water can rise against gravity from a water table is inversely proportional to the radius of the soil pores. Consequently, fine-textured clay soils with small pores exhibit a much higher capillary rise than coarse-textured sandy soils.

95. (C) A is true but R is false.
In Conservation Agriculture fields, thick surface crop residues physically intercept pre-emergence herbicides, reducing their contact with the soil. While this initial interception occurs, these herbicides are not permanently deactivated. Subsequent rainfall events can wash a portion of the intercepted herbicide off the residue and down into the soil weed germination zone.

96. (C) Carryover of inoculum for necrotrophic fungal diseases
Retaining crop residues on the soil surface in Conservation Agriculture fields provides significant soil health benefits but introduces disease management challenges. The primary risk is the carryover of inoculum for necrotrophic

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micro-aggregates. Within these micro-aggregates, organic carbon is physically shielded and isolated from microbial decomposers and oxygen. This physical protection drastically slows down the mineralization process, allowing organic carbon to accumulate and remain sequestered in the soil profile over long periods.

116. (C) High nutrient losses via ammonia volatilization, particularly when using urea
Applying nitrogenous fertilizers like urea directly onto the unplowed surface in conservation systems exposes the nutrients to elevated urease enzyme activity present in surface crop residues. This rapid enzymatic hydrolysis, combined with direct wind movement and solar exposure, converts urea into gaseous ammonia. Without physical incorporation into the soil matrix, substantial amounts of nitrogen are lost through volatilization.

117. (A) An increase in transpiration alongside a reduction in evaporation, raising the overall $\frac{T}{E}$ ratio
In Conservation Agriculture, the continuous presence of a protective surface crop residue mulch acts as a physical barrier that drastically limits solar radiation reaching the soil surface. This coverage reduces unproductive soil water evaporation. Consequently, a greater proportion of stored soil moisture is redirected toward productive crop transpiration, successfully raising the overall transpiration-to-evaporation ratio and improving efficiency.

118. (D) Since mechanical cultivation is absent, integrated weed management using diverse crop rotations and competitive cultivars becomes essential.
Because Conservation Agriculture strictly avoids mechanical soil disturbance and intensive tillage, farmers cannot rely on physical cultivation to destroy emerging weed cohorts. Therefore, logical deduction suggests that long-term weed control can only be sustained by employing integrated weed management. This strategy combines diverse crop crop-rotation schemes, cover cropping, and competitive crop cultivars to suppress weed populations naturally.

119. (B) Provide a microclimate habitat for both overwintering pests and beneficial predatory arthropods
Surface crop residues maintained under Conservation Agriculture create a highly buffered, humid, and insulated microclimate at the soil-atmosphere interface. This protective layer provides a physical habitat that supports the overwintering and survival of various agricultural pests. Simultaneously, however, it serves as an essential refuge and food source for beneficial predatory arthropods, leading to highly complex biological interactions.

120. (C) It incorporates active rotary blades that cut a narrow slit through heavy, loose surface residue
The Turbo Seeder, or Happy Seeder, incorporates an active mechanism of high-speed rotary flail blades mounted ahead of the seeding tynes. Unlike conventional zero-till drills, which get easily clogged by loose surface straw, these specialized blades physically cut, lift, and clear a narrow path through heavy crop residues, allowing precise, uninterrupted seed placement directly into untilled soil.

121. (D) Silvopasture or strict forestry
Under the Land Capability Classification system, Class VII lands possess highly severe, permanent physical limitations, such as steep slopes, extreme erosion hazards, or shallow soils, making them entirely unsuited for arable cultivation. Consequently, the most ecologically sustainable and protective land-use option for these fragile areas is establishing permanent vegetative covers, specifically through silvopasture or strict forestry.

122. (A) Has potential for vegetative cover development but is currently degraded or underutilized
A culturable wasteland refers to land that is biologically capable of supporting vegetation and agricultural crops but currently remains uncultivated and underutilized for more than five consecutive years. These lands are often degraded due to various physical or chemical constraints, yet they retain the inherent ecological potential to be restored and developed under productive vegetative systems.

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123. (B) Intense soil erosion, leaching of ash nutrients, and rapid oxidation of soil organic matter
Shifting cultivation, or Jhum, involves clearing and burning forest vegetation, which initially deposits nutrients as ash. However, without protective canopy cover, subsequent high-intensity tropical rainfall causes severe soil erosion and rapid leaching of these soluble ash nutrients. Simultaneously, exposing the forest soil to direct solar radiation accelerates the biological oxidation and depletion of soil organic matter.

124. (B) A rotational arrangement such as traditional shifting cultivation or managed improved fallows
Agroforestry systems can be arranged either spatially or temporally. When trees, agricultural crops, and pastures occupy the same land unit in a sequential timeframe rather than growing together at the same time, the system is classified as a rotational temporal arrangement. Classic examples include traditional shifting cultivation cycles and managed improved fallows using nitrogen-fixing woody species.

125. (A) Allelopathy
Black walnut trees synthesize the biological compound juglone, which is actively released into the surrounding soil environment through root exudation, leaf leaching, and organic decay. This chemical compound exerts a direct toxic effect on neighboring susceptible vegetation, actively inhibiting their germination and vegetative growth. This phenomenon of chemical-mediated plant-to-plant inhibition is scientifically classified as allelopathy.

126. (C) Elevated apical meristems on elongated internodes
Grass species subjected to intense grazing pressure depend on keeping their growing points safe from defoliation. Grasses with elevated apical meristems positioned on elongated internodes are highly vulnerable because grazing animals easily consume these growth points. Once removed, the plant cannot continue leaf elongation from that stem, making this trait highly disadvantageous compared to prostrate habits.

127. (D) Themeda-Arundinella temperate alpine types
The high-altitude ecological zones of the Himalayan mountain system feature cooler, temperate, and sub-alpine climatic conditions. These specific environmental parameters support distinct rangeland ecosystems that are naturally dominated by the Themeda-Arundinella grass cover association. This association is structurally adapted to cold environments, differentiating it from the tropical or dry-zone grass covers found in lowland India.

128. (C) The maximum number of grazing animals the land can sustain without degradation
Carrying capacity represents a fundamental ecological metric in sustainable pasture and rangeland management. It defines the maximum number of livestock or grazing animals that a specific area of land can successfully support over a defined timeframe. This threshold ensures that the animals receive adequate forage nutrition while preventing long-term structural soil compaction or vegetative degradation.

129. (B) They physically complex with proteins, rendering them resistant to rapid microbial enzymatic breakdown
Lignin and polyphenols are highly complex structural and chemical compounds present in mature plant tissues. When crop residues undergo decomposition, these polyphenolic molecules physically bind and complex with nitrogenous proteins and microbial enzymes. This chemical complexation reaction creates a highly stable, resistant barrier that effectively shields organic substrates from rapid enzymatic breakdown by soil microorganisms.

130. (D) Methane (CH_4)
In anaerobic environments where atmospheric oxygen is completely absent, specialized methanogenic archaea break down organic substrates. During the final stage of this biochemical digestion process, these microorganisms reduce intermediate carbon compounds, converting them into methane gas. Consequently, methane serves as the primary terminal carbon-based byproduct, which is widely captured for use as renewable biogas energy.

131. (A) Volatilization into the atmosphere
Arid environments are characterized by high ambient temperatures, low relative humidity, and limited soil moisture. Under these specific climatic conditions, plants producing volatile terpenoid compounds release these allelochemicals primarily through gaseous volatilization from

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leaf surfaces into the surrounding atmosphere. These airborne vapors eventually settle onto nearby soils, where they actively inhibit the germination of neighboring species.

132. (C) Dry tons of woody biomass per hectare per year
To evaluate the productivity and economic viability of bioenergy plantations utilizing Short-Rotation Intensive Culture, researchers require standardized metrics. Biomass yield is typically measured and expressed in terms of dry tons of woody biomass per hectare per year. Utilizing dry weight eliminates variations caused by fluctuating moisture content in freshly harvested wood, ensuring accurate quantification.

133. (A) Recognize complex patterns in datasets to predict crop yields from environmental variables
Artificial Neural Networks are computational systems modeled on the biological structure of human brains. In modern agricultural systems, these networks are trained to analyze large, multi-dimensional datasets containing weather, soil, and crop parameters. By recognizing highly complex, non-linear patterns within these datasets, neural networks can accurately predict seasonal crop yields and guide management decisions.

134. (D) Red and Near-Infrared (NIR)
The Normalized Difference Vegetation Index is a widely used remote sensing metric that assesses plant health and canopy density. This index is calculated by measuring the reflectance of light across two specific bands: red and near-infrared. Healthy, chlorophyll-rich vegetation absorbs a large proportion of visible red light while strongly reflecting near-infrared radiation back to drone sensors.

135. (A) Both A and R are true and R is the correct explanation of A.
In zero-tillage systems, the absence of mechanical soil inversion causes immobile plant nutrients, particularly phosphorus, to accumulate in the upper soil layer. During dry periods, this topsoil dries out, restricting root activity in that zone. Placing fertilizers deeply beneath this dry layer is highly effective because it ensures crop roots can access essential nutrients in moist subsoil.

136. (C) Speculative valuation of cryptocurrency assets owned by the farm operator
Ecological footprinting is a biophysical accounting tool that quantifies the total area of biologically productive land and water resources required to support a system. It evaluates resource flows, including energy inputs, chemical manufacturing, direct emissions, and land occupation. But it entirely excludes non-physical, speculative financial assets, such as digital cryptocurrency valuations, which carry no direct biological resource demand.

137. (D) Infiltration rate
Retaining crop residues on the soil surface protects the soil from the direct kinetic energy of raindrops, preventing surface sealing and crusting. This physical protection maintains soil pore continuity at the surface, allowing water to penetrate easily. Consequently, the soil water infiltration rate increases significantly, which reduces the volume and velocity of surface water runoff during storms.

138. (A) Stable organo-mineral complexes and recalcitrant humic molecules
Soil organic carbon sequestration is achieved by chemically and physically stabilizing decomposed plant litter within the soil matrix. During decomposition, microbial residues and humic substances bind tightly to silt and clay particles, forming highly stable organo-mineral complexes. These structures, along with recalcitrant humic molecules, resist microbial degradation, preserving carbon in the soil for long periods.

139. (B) A shift toward a fungally-dominated microbial community
Long-term conservation agriculture avoids soil tillage, which allows extensive networks of fungal hyphae to develop undisturbed. Additionally, retaining crop residues on the soil surface provides a continuous supply of complex, high-carbon organic substrates like lignin and cellulose. These conditions favor fungi, which decompose complex organic matter, leading to a biological shift toward a fungally-dominated microbial community.

140. (B) It decouples the surface from turbulent atmospheric boundaries, reducing vapor gradients
A surface mulch layer acts as a physical buffer that decouples the soil surface from the

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surrounding atmosphere. By shielding the soil from direct solar radiation and wind, it reduces surface temperatures and wind velocity at the boundary interface. This reduces the vapor pressure gradient between the soil pores and the air, significantly slowing down evaporative water loss.

141. (A) Surface-retained seeds show rapid initial emergence but undergo high predation and decay rates
In Conservation Agriculture, the absence of tillage leaves weed seeds concentrated on or near the soil surface. Exposed on the surface, these seeds experience high initial germination and emergence rates. However, they are also highly vulnerable to active predation by birds, insects, and small rodents, as well as rapid microbial decay caused by fluctuating surface moisture.

142. (C) Higher soil moisture and cooler temperatures under surface residue favor active fungal proliferation
Retaining crop residues on the soil surface creates a distinct microclimate characterized by higher moisture retention and cooler soil temperatures. While beneficial for crop water-use efficiency, these specific physical conditions are highly favorable for the survival and rapid growth of certain soil-borne fungal pathogens, such as Rhizoctonia. This can lead to increased root rot infections in susceptible crops.

143. (D) Reduction in turnaround time between crops
Using a zero-till drill allows direct planting into unplowed crop residue immediately after harvesting. This eliminates the need for multiple energy-intensive tillage passes, significantly reducing the turnaround time between crop seasons. This rapid establishment is particularly valuable in intensive double-cropping systems, allowing crops to be planted within their optimal window to maximize yield and farm profitability.

144. (C) Their biological capability to support cultivated arable crops safely
The USDA Land Capability Classification system divides land into eight classes based on physical limitations. Classes I through IV possess soil and slope characteristics that safely support long-term, intensive cultivation of arable crops with appropriate conservation practices. In contrast, Classes V through VIII have highly severe limitations, rendering them unsuited for crop cultivation and restricting usage.

145. (A) P-3, Q-4, R-1, S-2
Wastelands are classified by their primary degradation drivers. Gullied lands form from concentrated water runoff and erosion. Saline soils develop from poor drainage and high evaporation in semi-arid zones. Shifting cultivation areas suffer from short fallow cycles and burning. Degraded pastures result from overgrazing where animal numbers exceed the rangeland carrying capacity.

146. (D) Podu - Andhra Pradesh
Shifting cultivation is practiced globally under various traditional names. In India, regional nomenclature differs significantly across states. Jhum cultivation is the primary term utilized in Northeast India. Shifting agricultural practices in Central India are often called Bewar. In Andhra Pradesh and parts of Odisha, this slash-and-burn farming system is traditionally known as Podu.

147. (A) Protective
Shelterbelts consist of multiple rows of trees or shrubs planted in linear barriers perpendicular to prevailing winds. While they can provide secondary wood products, their primary functional role in agricultural landscapes is protective. They physically reduce wind velocity, thereby minimizing soil erosion, protecting delicate crops from wind damage, and reducing moisture loss from the surrounding soil.

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148. (C) Release of active chemical inhibitors into the environment
In agroforestry, tree-crop interactions involve both competitive and non-competitive mechanisms. Resource competition occurs when trees and crops actively contend for shared physical pools of light, water, and soil nutrients. In contrast, allelopathy is a chemical-mediated process characterized by the active synthesis and release of toxic chemical compounds into the surrounding rhizosphere, directly inhibiting nearby plant growth.

149. (A) Tiller
A grass plant is a modular organism constructed from multiple repeating structural units. The fundamental morphological unit is the tiller, which consists of a single lateral shoot originating

from the basal auxiliary buds on the crown. Each individual tiller possesses its own active apical meristem, leaves, nodes, internodes, and eventually its own adventitious root system.

150. (D) Arid and semi-arid plains of Western and Central India
The Dichanthium-Cenchrus-Lasiurus association represents one of India's major natural grass cover types. This specific plant community is highly adapted to low annual rainfall, high summer temperatures, and coarse-textured soils. Consequently, its primary natural habitat spans across the extensive arid and semi-arid plains of Western and Central India, including the Thar Desert of Rajasthan.

151. (B) Rapid invasion by unpalatable, toxin-producing weeds and thorny woody shrubs
When livestock grazing exceeds the carrying capacity of a pasture, selective grazing pressure depletes highly palatable and nutritious climax grasses. This continuous defoliation weakens desirable species and reduces their basal cover. This open ecological niche is rapidly colonized by invasive, unpalatable, toxin-producing weeds and thorny woody shrubs, signaling severe structural degradation of the rangeland ecosystem.

152. (C) Lignin
Plant residues consist of diverse organic fractions, including simple proteins, starches, cellulose, hemicellulose, and lignin. While microorganisms easily metabolize soluble carbohydrates and proteins, they struggle to degrade lignin. Lignin is a highly complex, amorphous polymer of aromatic alcohols that is hydrophobic and lacks repeating hydrolyzable bonds, rendering it exceptionally resistant to rapid microbial decomposition.

153. (D) To reintroduce atmospheric oxygen and guarantee highly uniform decomposition
Aerobic composting relies on active populations of oxygen-consuming microorganisms to break down organic waste. As decomposition proceeds, internal oxygen within the compost pile is rapidly consumed. Turning the compost physically agitates the pile, which reintroduces fresh atmospheric oxygen throughout the core. This process also mixes outer cooler materials into the active, hot center, ensuring uniform decomposition.

154. (A) Active biosynthesis and exudation from root hairs
Sorgoleone is a highly active lipid-like benzoquinone compound that acts as a powerful natural herbicide. This allelochemical is continuously synthesized in the cytoplasm of sorghum root hairs. Following its intracellular biosynthesis, it is actively exuded through the root hair tips directly into the surrounding soil, where it suppresses the germination and development of competing weeds.

155. (B) Carbon dioxide released in burning equals carbon fixed during the growth phase of the trees
Short-Rotation Intensive Culture plantations help mitigate greenhouse gas accumulation by operating within a closed biogenic carbon loop. When woody biomass is harvested and burned for energy, the carbon dioxide released into the atmosphere is equivalent to the amount of atmospheric carbon dioxide fixed by the trees during their active photosynthetic growth phase, resulting in zero net carbon addition.

156. (B) The model is trained on labeled data where targets (e.g. healthy vs diseased) are explicitly provided
Supervised machine learning algorithms rely on structured training environments to develop predictive capabilities. For crop disease classification, the model is fed a large dataset of plant images where each sample is paired with an explicit, human-verified label, such as healthy or infected. The algorithm learns to associate specific visual patterns with these pre-defined target categories to classify new data.

157. (A) Canopy temperature-based crop water stress indexes
Smart irrigation systems utilize Internet of Things networks to measure transpiration dynamics directly. When plants experience soil moisture deficits, their stomata close to conserve water, which reduces transpiration cooling and causes leaf temperatures to rise. High-resolution infrared sensors monitor these canopy temperature changes in real time, calculating stress indexes to trigger automated irrigation systems when needed.

158. (C) Fair agricultural labor practices and rural community resilience
Sustainable agricultural frameworks assess the viability of farming across environmental,

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CHAPTER 09
Basics of Soil and Water

2006

1. Which soil physical property primarily dictates the proportion of capillary to non-capillary pores and fundamentally governs water retention capacity?
(A) Soil bulk density
(B) Soil texture
(C) Soil structure
(D) Soil color

2018

2. What is the standard equation for the catchment water balance over a specified time period?
(A) $P = Q - E + \Delta S$
(B) $P = Q \times E + \Delta S$
(C) $P + Q = E - \Delta S$
(D) $P = Q + E + \Delta S$

2004

3. Which component of soil water potential is predominantly responsible for water movement in saturated soils?
(A) Gravitational potential
(B) Osmotic potential
(C) Matric potential
(D) Solute potential

2003

4. What is the standard matric potential range typically associated with Field Capacity in medium-textured soils?
(A) -1.5 to -2.0 MPa
(B) -0.1 to -0.5 MPa
(C) -0.01 to -0.033 MPa
(D) -3.1 to -4.0 MPa

2005

5. In the Soil-Plant-Atmosphere Continuum (SPAC), what primarily drives the continuous ascent of water from roots to leaves?
(A) Transpiration-induced tension gradient
(B) Active solute transport in xylem vessels
(C) Root pressure from metabolic respiration
(D) Capillarity within narrow phloem tubes

2010

6. Which process represents the volume of precipitation temporarily retained in small surface depressions before infiltrating or evaporating?
(A) Canopy interception
(B) Stemflow
(C) Surface runoff
(D) Depression storage

2012

7. During a double-ring infiltrometer test, what is the primary function of the outer ring?
(A) To measure vertical percolation velocity directly
(B) To prevent lateral water flow from the inner ring
(C) To record cumulative infiltration depth over time
(D) To minimize surface runoff losses during measurement

2023

8. How does an increase in the topographic slope of a catchment generally affect the infiltration rate, assuming all other factors remain constant?
(A) It increases infiltration rate by enhancing downslope gravitational head
(B) It has no effect since soil texture remains the primary governing factor
(C) It decreases infiltration rate by reducing water opportunity time on soil
(D) It initially increases infiltration then causes rapid sealing of surface

NODIA

2011

9. Which agronomic amendment is most effective for improving the infiltrability of a highly sodic soil?
(A) Agricultural lime
(B) Rock phosphate
(C) Urea
(D) Gypsum

2003

10. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):

many resource-poor smallholders do not own or cannot afford.

167. (B) Extremely few physical limitations restricting intensive agricultural use
Under the USDA Land Capability Classification system, Class I land represents the highest quality soil for agricultural production. This land is characterized by flat or nearly level topography, deep and well-drained soils, excellent water-holding capacity, and high natural fertility. Consequently, it has extremely few physical limitations, allowing safe, intensive, and continuous cultivation of arable crops.

168. (C) Marine water intrusion triggered by over-extracting coastal aquifers
Coastal saline wastelands develop due to high salt concentrations in the soil profile near coastlines. The primary driver is marine water intrusion into freshwater aquifers, which is triggered by the excessive extraction of groundwater for domestic and agricultural use. As seawater moves inland to replace the extracted water, it elevates groundwater salinity, salinizing the agricultural root zone.

169. (D) Integrating Alnus nepalensis trees into fallow cycles to speed up soil nitrogen fixation
To restore soil fertility in Jhum cultivation areas where fallow periods have shortened, agroforestry interventions are implemented. A key restorative model involves integrating Alnus nepalensis, a native nitrogen-fixing tree species, into the fallow cycle. These trees rapidly fix atmospheric nitrogen through symbiotic root nodules, speed up biomass accumulation, control erosion, and drastically accelerate the recovery of soil nutrients.

170. (A) Ecological classification
Agroforestry systems can be categorized using several distinct classification criteria. While structural classifications focus on component mixtures and functional classifications look at roles, ecological classification organizes systems based on their environmental adaptation. This classification groups agroforestry systems according to the specific climatic and ecological zones they are suited for, such as arid, semi-arid, temperate, or humid tropical regions.

171. (B) Reduced growth and germination of understory crops caused by released phytotoxins
In agroforestry, trees and understory crops share the same land unit, leading to chemical interactions. Allelopathic interference occurs when tree species synthesize and release active phytotoxins into the surrounding soil or atmosphere. These chemical compounds actively disrupt the physiological processes of adjacent crops, leading to reduced seed germination and stunted vegetative growth in the understory.

172. (B) True grasses (Gramineae/Poaceae)
Agrostology is a specialized branch of botany and agricultural science. It is dedicated specifically to the scientific study of true grasses, which belong to the taxonomic families Gramineae or Poaceae. This field of study encompasses grass taxonomy, morphology, distribution, and ecological adaptation, which are essential for managing rangelands, pastures, lawns, and cereal crop production.

173. (A) Danthonia and Phleum species
The high-altitude alpine and sub-alpine regions of the Himalayan range feature extreme cold, short growing seasons, and frost. These conditions support specialized cold-tolerant grass communities. The dominant vegetative cover in these high mountain rangelands consists of species from the Danthonia and Phleum genera, which are structurally adapted to thrive in temperate alpine soils and climates.

174. (C) Rotational grazing
Rotational grazing is an intensive pasture management system that divides a large rangeland into smaller, fenced paddocks. Livestock graze a single paddock for a brief period before being physically moved to another fresh paddock. This systematic movement allows the recently grazed pasture a defined period of rest to regrow vegetative biomass, improving overall forage productivity.

175. (C) A is true but R is false.
Cereal residues possess a high carbon-to-nitrogen ratio compared to nitrogen-rich leguminous residues. When soil microorganisms decompose high carbon-to-nitrogen cereal residues, they require more nitrogen than is available in the residue. Consequently, they absorb inorganic nitrogen from the surrounding soil solution,

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causing biological immobilization rather than the immediate release or mineralization of nitrogen.

176. (C) Maintaining a completely oxygen-free environment in a vessel
Anaerobic composting depends on specialized groups of acid-forming and methanogenic bacteria that decompose organic matter. These specific microbial groups are obligate anaerobes, meaning their metabolic pathways are actively poisoned or halted by the presence of oxygen. Therefore, maintaining a completely oxygen-free environment within a sealed vessel or digester is essential for optimal anaerobic digestion.

177. (B) Sunflower residues inhibiting the growth of subsequent crops like mustard or linseed
Crop-to-crop allelopathy occurs when chemical compounds released from the residues of one crop actively suppress a subsequent crop. A classic example is sunflower residue, which contains high concentrations of terpene and phenolic allelochemicals. When these residues decompose in the soil, they release phytotoxins that inhibit the seed germination and early growth of subsequent crops like mustard or linseed.

178. (B) 2 to 10 years
Short-Rotation Intensive Culture is a high-density tree planting system optimized for rapid woody biomass production. Unlike traditional forestry systems that require several decades to reach harvestable maturity, bioenergy energy plantations utilize fast-growing tree species. These species are typically harvested on brief rotational cycles ranging from two to ten years, maximizing fuel feedstock output.

179. (A) Deep Learning utilizing multi-layered Convolutional Neural Networks
Computer vision systems in modern agriculture automate the visual inspection of crops to detect disease, pests, or nutrient deficiencies. This technology relies on deep learning architectures, specifically multi-layered Convolutional Neural Networks. These specialized neural networks process digital crop images through successive layers, automatically extracting spatial features like color, shape, and texture to classify crop health.

180. (C) Recommending the precise rate, timing, and spatial location for applying chemical inputs
Precision farming integrates spatial and temporal data with Artificial Intelligence decision support systems to optimize field operations. Rather than managing fields uniformly, these systems analyze sensor data to recommend the exact application rates, precise timing, and specific spatial locations for chemical inputs like fertilizers and pesticides, maximizing nutrient efficiency and protecting environmental resources.

181. (A) Biologically productive land and water needed to sustain a specific agricultural system
An ecological footprint analysis is a comprehensive resource accounting tool used to assess sustainability. This methodology quantifies the total area of biologically productive land and water resources required to produce the inputs consumed and to safely absorb the waste generated by a specific agricultural system, comparing this demand against the earth's natural biocapacity.

182. (D) Enhancing soil water infiltration while reducing surface runoff velocity
Shifting from conventional tillage to Conservation Agriculture alters the physical and biological properties of the soil profile. Retaining surface residue mulches protects the surface from rain impact, preventing crust formation. Undisturbed soil maintains continuous vertical macropores, which enhances soil water infiltration. This combination increases the soil water content while significantly reducing surface runoff velocity and erosion.

NODIA

183. (B) Implementing Alternate Wetting and Drying (AWD)
Continuous flooding in traditional rice paddies creates highly anaerobic soil conditions, which encourages methanogenic archaea to produce substantial methane emissions. Implementing Alternate Wetting and Drying mitigates this greenhouse gas release. By periodically draining the field to introduce atmospheric oxygen into the soil, methanogenesis is actively suppressed, significantly lowering overall methane emissions without reducing crop yield.

184. (C) It accumulates primarily in the shallow upper zero to five centimeter soil layer
Phosphorus is a highly immobile chemical element in the soil solution, binding tightly to

soil minerals. In strict Conservation Agriculture systems, tillage is avoided, preventing the mechanical incorporation and mixing of surface-applied inputs. Consequently, over multiple crop seasons, applied phosphorus fertilizer accumulates primarily within the shallow upper zero to five centimeter layer of the soil profile.

185. (A) P-1, Q-4, R-3, S-2
Agricultural Artificial Intelligence applications rely on diverse specialized concepts. The Internet of Things deploys wireless soil sensor networks. Convolutional Neural Networks analyze digital crop images to identify plant diseases. Predictive Analytics processes environmental databases to forecast seasonal yields. Autonomous Robotics automates mechanical weeding and harvesting operations, reducing agricultural dependency on manual farm labor.

186. (A) Lack of tillage avoids bringing buried seeds up to shallow depths optimal for germination
Phalaris minor is a major annual weed affecting wheat cultivation, requiring specific environmental conditions to germinate. In zero-tillage systems, the absence of mechanical soil disturbance leaves weed seeds undisturbed in deeper soil layers. Because these seeds are not brought up to the shallow, light-exposed surface depths optimal for germination, their emergence rates decline.

187. (B) The rate of decomposition of the infected crop residue substrate
Under Conservation Agriculture systems, plant residues are retained on the soil surface rather than plowed under. Soil-borne pathogens survive during fallow periods primarily within this infected organic substrate. Consequently, the pathogens' survival is heavily dependent on the decomposition rate of these residues; faster decay deprives pathogens of their protective habitat, reducing inoculum levels.

188. (B) Happy Seeder
Direct sowing into heavy, unplowed residue from preceding crops is a major challenge in Conservation Agriculture. The Happy Seeder is a specialized tractor-mounted machine designed to address this. It integrates a flail-type rotary cutter that cuts and lifts loose residue ahead of the sowing tynes, plants the seed, and deposits the cut straw back as surface mulch.

189. (D) Class VI
The USDA Land Capability Classification system categorizes land units from Class I to VIII. Class VI land is characterized by severe, permanent physical limitations, such as steep slopes, high erosion susceptibility, stoniness, or shallow soils, making it entirely unsuited for arable cultivation. Its safe and sustainable use is restricted to pasture, rangeland, woodland, or wildlife preservation.

190. (C) Barren rocky areas, snow-covered peaks, and steep glaciated regions
Wastelands are classified by remote sensing agencies based on their physical restoration potential. Unculturable wastelands refer to lands characterized by extreme physical constraints that completely prevent any biological growth or agricultural development. This category primarily includes barren rocky outcrops, permanent snow-covered peaks, steep glaciated regions, and high-altitude cold deserts, which cannot be reclaimed using conventional methods.

191. (D) High population density has severely compressed fallow periods, stopping natural soil nutrient recovery
Traditional shifting cultivation relies on long forest fallow cycles of fifteen to thirty years to restore soil fertility. Today, rapid population growth and land constraints have severely compressed these fallow periods to just three to five years. This short timeframe prevents the natural regeneration of woody vegetation and soil nitrogen-fixation processes, leading to permanent nutrient depletion.

NODIA

192. (C) Agrisilvicultural
Agroforestry systems are structurally categorized based on their component combinations. A system that integrates annual agricultural crops with woody perennials, such as timber or fruit-bearing trees, on the same land unit is defined as an agrisilvicultural system. This design optimizes the spatial and temporal use of light, water, and soil nutrients between herbaceous crops and deep-rooted trees.

193. (B) Minimize underground crop-tree competition for water and soil nutrients
In agrisilvicultural systems, trees and shallow-rooted agricultural crops share the same soil volume, leading to competitive interactions. Tree root systems often expand laterally into

economic, and social dimensions. While soil health and financial profits cover environmental and economic goals, the social pillar prioritizes human equity and community welfare. Consequently, core social indicators focus on ensuring fair agricultural labor practices, promoting safe working conditions, and strengthening the overall socio-economic resilience of rural farming communities.

159. (D) Yield stagnation or decline despite stable or increasing inputs
The System Sustainability Index tracks the long-term balance between agricultural resource inputs and crop outputs. A steady decline in this index over a ten-year timeframe in intensive rice-wheat cropping systems indicates a fundamental loss of efficiency. It suggests that crop yields are stagnating or declining despite the continued or increased application of synthetic fertilizers, water, and other external inputs.

160. (C) It requires the incorporation of all crop residues into the plow layer
Conservation Agriculture is defined by three core agronomic principles: minimal soil disturbance, diverse crop rotations, and permanent organic soil cover. Rather than incorporating crop residues into the soil profile via intensive plowing, this conservation management system strictly requires maintaining all harvested plant residues on the soil surface as a protective mulch layer to prevent erosion and conserve moisture.

161. (B) Nitrous oxide (N_2O)
Applying synthetic nitrogenous fertilizers to cultivated soils increases the availability of ammonium and nitrate ions in the soil solution. These inorganic nitrogen compounds undergo biological transformations carried out by soil microbes through the sequential processes of nitrification and denitrification. Nitrous oxide is released as an intermediate gaseous byproduct of these processes, representing a highly potent greenhouse gas.

162. (D) Phosphorus accumulates near the soil surface, limiting crop uptake if that top layer dries out
In zero-tillage systems, the absence of physical soil mixing combined with the surface application of phosphorus causes this highly immobile nutrient to accumulate in the top few centimeters of the soil profile. This phenomenon is known as stratification. If the surface soil dries out during dry spells, crop roots cannot absorb phosphorus from this layer, leading to deficiency.

163. (A) Reducing surface soil evaporation, conserving more profile moisture for transpiration
Maintaining a dense layer of crop residues on the soil surface protects the soil from direct solar radiation and wind. This physical barrier significantly reduces evaporation from the soil surface. By conserving water that would otherwise be lost unproductively to the atmosphere, the crop retains more soil moisture for productive transpiration, resulting in higher overall water-use efficiency.

164. (C) The continuous lack of deep soil inversion fails to disrupt vegetative perennating structures and rhizomes
In Conservation Agriculture, the complete absence of intensive plowing and mechanical soil inversion creates a stable underground environment. Because the soil is left undisturbed, the underground vegetative perennating structures, tubers, bulbs, and rhizomes of perennial weeds remain completely intact and viable. This allows perennial weeds to establish and spread, causing a shift from annual to perennial weed populations.

165. (A) Antagonistic and competitive interactions from a highly active, diverse soil microbiome
Long-term Conservation Agriculture improves soil health by providing a continuous supply of diverse carbon substrates and avoiding mechanical disturbance. These conditions foster a highly active and diverse soil microbial community. This abundant microbiome actively suppresses plant pathogens through biological competition for nutrients, direct parasitism, and the secretion of natural antagonistic compounds, creating a disease-suppressive soil environment.

166. (D) High upfront purchasing costs combined with the requirement of utilizing a higher horsepower tractor (>50 HP)
The Happy Seeder is an effective technology for direct sowing into heavy crop residues, but its adoption among smallholder farmers is limited. The machine has a high capital cost that is often prohibitively expensive. Additionally, it requires a higher horsepower tractor, typically exceeding fifty horsepower, to operate, which

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and red light reflectance. This allows artificial intelligence algorithms to evaluate crop canopy greenness, assess photosynthetic activity, and map crop health and density variations across large production fields in real time.

203. (B) Ensuring economic viability while maintaining equitable resource distribution pathways
Sustainable agriculture is structured upon three main pillars: environmental health, economic profitability, and social equity. To satisfy the crucial socio-economic dimension, farming systems must look beyond short-term financial gains. They must ensure long-term economic viability for farmers while actively maintaining fair labor standards and supporting equitable resource distribution pathways within the rural farming community.

204. (B) Integrates ecological, economic, and social performance indicators over time
Simple crop yield data only measures output, ignoring resource depletion and social impacts. In contrast, the System Sustainability Index provides a superior evaluation by integrating diverse ecological, economic, and social performance indicators over time. This multidimensional approach allows agronomists to assess whether productivity is being sustained at the expense of environmental degradation or social inequity.

205. (A) Degradation of soil structure and accelerated oxidative loss of organic matter
Conventional intensive tillage operations use heavy mechanical implements to repeatedly invert and break the soil profile. This physical disruption shears soil aggregates, degrading the natural soil structure. Additionally, the intensive aeration of the soil profile exposes protected organic carbon to microbial access, accelerating the oxidative loss of organic matter as carbon dioxide into the atmosphere.

206. (C) Storing more carbon in the soil pool than is emitted by general farming activity
Agricultural carbon sequestration strategies focus on mitigating climate change by manipulating carbon inputs and outputs. To achieve a net negative greenhouse gas profile, management practices like conservation tillage, cover cropping, and residue retention are implemented. These practices successfully capture and store more atmospheric carbon in the soil organic carbon pool than is emitted by farming operations.

207. (D) Sub-surface banding using coulter-equipped drills
In heavy-residue zero-tillage systems, broadcasting nitrogen fertilizers on the soil surface leads to severe losses from immobilization and ammonia volatilization. To avoid this, specialized sub-surface banding techniques are used. Coulter-equipped drills physically cut through the thick crop residue on the surface, placing a concentrated band of nitrogen fertilizer beneath the residue layer directly into the moist soil.

208. (B) It lowers soil temperature in summer and buffers against extreme cold in winter
A surface mulch layer of crop residues acts as an effective thermal insulator for the soil profile. In the hot summer, the residue reflects solar radiation, lowering soil temperatures. In the winter, it traps heat, buffering against extreme cold. Consequently, soil temperature fluctuations are significantly reduced, protecting beneficial soil microbes and crop root systems.

NODIA

209. (B) Distributed relatively uniformly throughout the active plow layer (typically 0 to 15 or 20 cm)
The choice of tillage system strongly influences weed seed bank dynamics within the soil profile. While Conservation Agriculture leaves weed seeds concentrated on the soil surface, conventional intensive tillage operations invert the soil profile. This physical inversion distributes weed seeds relatively uniformly throughout the active plow layer, typically extending down to fifteen or twenty centimeters.

210. (D) Foliar pathogens decline, while residue-borne pathogens may increase absent proper crop rotations
Conservation Agriculture changes disease dynamics within crop fields. By maintaining a surface layer of crop residues, the physical splashing of soil-borne pathogens onto lower leaves is reduced, causing a decline in foliar diseases. However, these residues can serve as overwintering sites for residue-borne pathogens, potentially increasing disease pressure if diverse crop rotations are not implemented.

****

the crop rooting zone. Performing systematic tree root pruning restricts lateral root growth, forcing roots to grow deeper. This minimizes underground competition between trees and crops for vital soil moisture and nutrients.

194. (D) Apical dominance mediated by auxins
In grass biology, tillering is a vital developmental process that determines canopy density and forage yield. This branching is physiologically regulated by apical dominance, which is mediated by auxin hormones synthesized in the primary shoot tip. Auxin transported downwards actively suppresses the activation and growth of basal auxiliary buds, while removing the shoot tip releases this inhibition, promoting tillering.

195. (A) Cenchrus ciliaris
The desert climate of Rajasthan is characterized by extreme high temperatures, low and erratic precipitation, and sandy soils with low water retention. Cenchrus ciliaris, commonly known as buffel grass, is highly adapted to these harsh desert conditions. It possesses a deep, extensive root system and physiological mechanisms that allow it to survive droughts and produce livestock forage.

196. (C) Inter-annual rainfall variation and its direct impact on forage production
Carrying capacity is not a static number but a dynamic rangeland metric. In arid and semi-arid grazing ecosystems, annual forage production is directly linked to soil moisture availability. Consequently, significant inter-annual rainfall variation causes major fluctuations in grass biomass. This directly alters the carrying capacity, requiring managers to adjust livestock herd sizes to prevent overgrazing during droughts.

197. (A) Rapidly, because cellulose is easily broken down by microbial cellulase enzymes
Decomposition rates of organic materials are governed by their chemical composition. Residues containing high cellulose but low lignin contents decompose rapidly. Although cellulose has a complex crystalline structure, it is a linear polymer of glucose that many soil bacteria and fungi can easily hydrolyze using highly efficient cellulase enzymes, especially when lignin shielding is absent.

198. (D) Persist for centuries, improving carbon storage and retaining soil water
Biochar is a highly stable, carbon-rich product generated through the pyrolysis of organic biomass. The primary agronomic advantage of incorporating biochar into cultivated fields is its high resistance to microbial oxidation. This stability allows biochar to persist in the soil profile for centuries, providing long-term carbon storage while its highly porous structure permanently enhances water retention.

199. (B) Root exudation and leaching from decomposing leaf residues
Phenolic acids represent a major class of water-soluble allelochemicals synthesized by many plant species. These phytotoxic compounds are released into the surrounding soil environment through two main pathways. First, living plants actively secrete them into the rhizosphere via root exudation. Second, these compounds are washed out of decaying leaf litter on the surface during rainfall.

200. (C) Thermochemical conversion to generate usable off-grid electricity or heat
Energy plantations are designed to maximize woody biomass production in brief timeframes. By utilizing Short-Rotation Intensive Culture, these systems establish fast-growing, high-density tree crops that are harvested repeatedly. This harvested woody biomass serves as a clean, renewable feedstock specifically optimized for thermochemical conversion processes, which combust or gasify the material to generate usable electricity and heat.

201. (D) The basic artificial neural perceptron
An Artificial Neural Network is a computational architecture inspired by the biological nervous system. The fundamental building block of this system is the artificial neuron, or perceptron. The perceptron receives multiple numerical agronomic inputs, applies mathematical weights and biases to them, and processes the sum through an activation function to generate a predictive output signal.

202. (A) Normalized Difference Vegetation Index
The Normalized Difference Vegetation Index is a fundamental remote sensing parameter used in precision agriculture. Calculated from multispectral image data, this index normalizes the difference between near-infrared

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Assertion (A): The SCS Curve Number method requires higher curve numbers for soils with high infiltration capacities.
Reason (R): Higher curve numbers indicate greater runoff potential.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2002
11. Which component of a basic hydrograph represents the gradual depletion of water stored in the catchment after rainfall ceases?
(A) Rising limb
(B) Recession limb
(C) Peak flow
(D) Baseflow separation point

2004
12. Which stage of water erosion is characterized by the uniform removal of a thin layer of topsoil over an entire field without forming visible channels?
(A) Rill erosion
(B) Sheet erosion
(C) Splash erosion
(D) Gully erosion

2005
13. In the Universal Soil Loss Equation (USLE), what does the 'C' factor represent?
(A) Crop management factor
(B) Conservation practice factor
(C) Climate erosivity factor
(D) Catchment shape factor

2011
14. Which biological soil-water conservation measure involves planting alternating bands of erosion-permitting and erosion-resisting crops along the contour?
(A) Mulching
(B) Cover cropping
(C) Strip cropping
(D) Contour farming

2012
15. Match the mechanical conservation measures with their primary suitability:
List I: (Mechanical conservation measures)
P. Contour bunding
Q. Graded bunding
R. Bench terracing
S. Trenching
List II: (Primary suitability)
1. Slopes up to 6% in high rainfall areas
2. Steep slopes (16-33%)
3. Slopes up to 6% in low rainfall areas ($<$ 600 mm)
4. Non-agricultural hilly wastelands
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-1, Q-4, R-2, S-3
(D) P-3, Q-1, R-2, S-4

NODIA

2013
16. Which of the following agroforestry interventions is primarily designed to act as a vegetative barrier reducing runoff velocity on sloping lands?
(A) Silvopastoral systems
(B) Alley cropping with deep-rooted trees
(C) Contour hedge planting
(D) Windbreaks

2009
17. What is the fundamental difference between a farm pond and a percolation tank in ex-situ rainwater harvesting?
(A) Farm ponds focus primarily on surface water storage, whereas percolation tanks target deep underground aquifers
(B) Farm ponds store surface water for direct utilization, whereas percolation tanks facilitate groundwater recharge
(C) Farm ponds always require structured emergency spillways, whereas percolation tanks function without spillways
(D) Farm ponds must be constructed on primary drainage lines, whereas percolation tanks are built on high ridgelines

2005
18. Supplemental irrigation using harvested rainwater is most critical for maximizing yield when applied during which growth stage of a cereal crop?
(A) Seedling emergence and establishment
(B) Active tillering and vegetative growth
(C) Anthesis and grain filling initiation
(D) Late physiological crop maturity stage

2004
19. According to the standard area-based classification in India, what is the typical size range of a micro-watershed?
(A) 1 to 100 hectares
(B) 100 to 500 hectares
(C) 500 to 1000 hectares
(D) 1000 to 5000 hectares

packing density
(D) By promoting rapid germination of weed seeds in the topsoil

2012

40. Consider the following statements concerning mechanical soil conservation measures:
I. Contour bunding is recommended for high rainfall areas to drain excess water.
II. Bench terracing converts steep slopes into a series of level or nearly level steps.
III. Graded bunding involves constructing bunds with a slight longitudinal slope.
IV. Trenching is primarily used for in-situ moisture conservation in non-arable lands.
V. Mechanical measures are generally less expensive than biological measures.
Which of the above statements are correct?
(A) I, II, III, and IV
(B) II, III, and IV
(C) I, III, IV, and V
(D) II, IV, and V

2023

41. Which agroforestry system is specifically characterized by growing crops between hedgerows of planted shrubs and trees to control erosion?
(A) Taungya system
(B) Shelterbelts
(C) Homegardens
(D) Alley cropping

2017

42. In the design of a farm pond, what is the primary purpose of providing a core wall in the earthen embankment?
(A) To prevent seepage of water through the earthen embankment
(B) To increase the height and volume of the earthen embankment
(C) To provide a safe and stable pathway for emergency overflow
(D) To anchor the concrete spillway structure to the foundation

2022

43. Which technique is most relevant for minimizing evaporation losses from the surface of a harvested farm pond in arid regions?
(A) Increasing the surface area to depth ratio
(B) Applying cetyl alcohol over the water surface
(C) Constructing the pond with a shallow depth
(D) Aerating the water continuously

2013

44. What characterizes a sub-watershed according to Indian standard geomorphological delineations?
(A) Area between 1 and 100 hectares
(B) Area between 1,000 and 5,000 hectares
(C) Area between 10,000 and 50,000 hectares
(D) Area exceeding 50,000 hectares

2015

45. Select the correct sequence of watershed delineation units from smallest to largest geographical area:
(A) Sub-watershed → Mini-watershed → Micro-watershed
(B) Micro-watershed → Mini-watershed → Sub-watershed
(C) Mini-watershed → Micro-watershed → Sub-watershed
(D) Micro-watershed → Sub-watershed → Mini-watershed

2008

46. What is the primary role of a 'transect walk' in Participatory Rural Appraisal (PRA) for watershed management?
(A) To resolve local property and land boundary disputes among village farmers
(B) To calculate the exact topographic slope using professional surveying instruments
(C) To systematically observe and discuss ecological and farming conditions with locals
(D) To establish and physically lay out contour bunds along the agricultural fields

2014

47. A prolonged meteorological drought inevitably leads to which subsequent form of drought if precipitation deficits continue?
(A) Socio-economic drought
(B) Hydrological drought
(C) Climatic drought
(D) Agricultural drought

2002

48. In contingent crop planning for early withdrawal of the monsoon, which harvest strategy is typically advised to secure economic returns?
(A) Delaying harvest to allow late grain filling
(B) Applying heavy irrigation to sustain the crop
(C) Harvesting the crop for fodder if grain setting fails
(D) Leaving the crop to dry completely in the field before harvest

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2022

30. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):

Assertion (A): Interception loss is generally higher in dense coniferous forests compared to broad-leaved deciduous forests during light rainfall events.

Reason (R): Coniferous needles provide a larger total surface area and aerodynamic roughness for retaining water droplets.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2013

31. What defines the final, constant rate of water entering the soil profile after prolonged wetting?
(A) Initial infiltration rate
(B) Cumulative infiltration
(D) Sorptivity
(D) Basic infiltration rate

2005

32. Which pedological factor most drastically limits the downward movement of infiltrating water, leading to rapid surface runoff?
(A) High concentration of well-decomposed organic matter
(B) Well-developed granular structure in the upper horizon
(C) Presence of a dense subsoil hardpan or argillic clay
(D) Uniformly coarse sandy texture throughout the profile

2010

33. Which of the following soil amendments improves infiltrability primarily through the enhancement of soil aggregation by microbial action?
(A) Sand application
(B) Farmyard manure
(C) Gypsum
(D) Calcium carbonate

2012

34. In the Rational formula ($Q = C \times I \times A$) for peak runoff estimation, what does the coefficient 'C' represent?
(A) Catchment shape factor
(B) Curve number
(C) Channel roughness
(D) Runoff coefficient

NODIA

2017

35. Match the runoff generation mechanisms with their defining conditions:

List I: (Runoff generation mechanisms)
P. Hortonian overland flow
Q. Saturation overland flow
R. Subsurface flow
S. Return flow

List II: (Defining conditions)
1. Water table rises to the surface
2. Rainfall intensity exceeds infiltration capacity
3. Groundwater exfiltrates to the surface
4. Lateral movement of water in the vadose zone

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-4, S-1
(D) P-4, Q-1, R-2, S-3

2002

36. Which hydrological term refers to the time elapsed from the centroid of effective rainfall to the peak of the direct runoff hydrograph?
(A) Time of concentration
(B) Lag time
(C) Time to peak
(D) Base time

2011

37. What is the initiating mechanism of water erosion that detaches soil particles and destroys soil structure upon impact?
(A) Splash erosion
(B) Sheet flow
(C) Rill erosion
(D) Channel erosion

2023

38. Which factor in the Universal Soil Loss Equation represents the intrinsic susceptibility of a soil to erosion based on its physical and chemical properties?
(A) R factor
(B) LS factor
(C) P factor
(D) K factor

2023

39. How does organic mulching primarily contribute to soil-water conservation?
(A) By accelerating evaporation rates from the upper soil profile
(B) By absorbing kinetic energy of rain and reducing runoff speed
(C) By increasing overall soil bulk density and

2024

20. Consider the following statements regarding Participatory Rural Appraisal (PRA) techniques in watershed management:

I. PRA relies heavily on top-down decision making by government engineers.

II. Resource mapping is a common PRA tool used to understand local assets.

III. PRA empowers local communities to identify their own problems and solutions.

Which of the above statements are correct?

(A) I and II

(B) II and III

(C) I and III

(D) I

2018

21. Which type of drought is defined strictly by a prolonged period with less than average precipitation in a specific region?

(A) Meteorological drought

(B) Agricultural drought

(C) Hydrological drought

(D) Socio-economic drought

2007

22. Which contingent crop planning strategy is most appropriate for a severely delayed monsoon onset (e.g., late August) in a semi-arid region?

(A) Sowing long-duration cereal varieties

(B) Increasing the application rate of basal nitrogen fertilizer

(C) Pre-sowing irrigation using deep groundwater

(D) Shifting from cereals to short-duration pulses or oilseeds

2008

23. Which mid-season agronomic correction is most effective for reducing inter-plant competition for moisture during a prolonged dry spell?

(A) Gap filling

(B) Thinning of crop stands

(C) Top dressing with nitrogen

(D) Deep inter-cultivation

2004

24. Which of the following chemicals acts as a stomata-closing type anti-transpirant?

(A) Kaolin

(B) Cycocel (CCC)

(C) Phenyl mercuric acetate (PMA)

(D) Hexadecanol

2009

25. Consider the following statements regarding soil bulk density and porosity:

I. Tillage operations permanently decrease soil bulk density.

II. Organic matter application generally decreases soil bulk density.

III. Porosity is inversely related to soil bulk density.

IV. Sandy soils typically possess higher total porosity than clay soils.

Which of the above statements are incorrect?

(A) I and III

(B) II, III, and IV

(C) I and IV

(D) I, II, and IV

2023

26. Which component of the hydrologic cycle is responsible for returning the largest volume of water to the atmosphere from terrestrial ecosystems?

(A) Evapotranspiration

(B) Direct evaporation from soil

(C) Sublimation

(D) Canopy interception evaporation

2010

27. In a highly saline soil, which water potential component becomes significantly negative, severely restricting root water uptake?

(A) Matric potential

(B) Osmotic potential

(C) Gravitational potential

(D) Pressure potential

2014

28. Which soil moisture constant represents the lower limit of soil water available to plants, typically occurring at -1.5 MPa?

(A) Field Capacity

(B) Permanent Wilting Point

(C) Hygroscopic Coefficient

(D) Saturation Capacity

2013

29. During periods of high transpirational demand, what causes a temporary loss of turgor in plant leaves even if soil moisture is near field capacity?

(A) Transpiration rate exceeding the rate of water absorption

(B) Root resistance exceeding the soil hydraulic conductivity

(C) Cavitation in the phloem

(D) Accumulation of abscisic acid in the roots

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2005
49. Which agronomic practice minimizes soil moisture loss during a mid-season dry spell without altering plant population density?
(A) Application of expensive chemical desiccants to leaves
(B) Soil mulch creation via shallow inter-cultivation
(C) Selective pruning of senescent lower plant leaves
(D) Intensive weeding of non-crop species between rows

2024
50. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Film-forming anti-transpirants like hexadecanol create a physical barrier on the leaf surface.
Reason (R): This barrier significantly reduces transpiration without affecting photosynthesis rates.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2021
51. Which soil structural class exhibits the highest overall total porosity and highest water retention capacity at saturation?
(A) Crumb
(B) Platy
(C) Prismatic
(D) Blocky

2005
52. In a typical catchment water balance, what does the parameter ΔS denote?
(A) Change in sediment yield and soil erosion rate
(B) Change in surface elevation and basin topography
(C) Change in soil moisture and groundwater storage
(D) Total surface runoff and streamflow discharge

2008
53. Which potential is generally neglected when measuring water movement within unsaturated horizontal soil columns?
(A) Gravitational potential
(B) Matric potential
(C) Osmotic potential
(D) Pressure potential

2007
54. Available Water Capacity (AWC) is quantitatively defined as the difference in soil moisture content between which two constants?
(A) Saturation and Field Capacity
(B) Permanent Wilting Point and Hygroscopic Coefficient
(C) Saturation and Hygroscopic Coefficient
(D) Field Capacity and Permanent Wilting Point

2006
55. Match the water potential components with their primary governing factors:
List I: (Water potential components)
P. Matric potential
Q. Osmotic potential
R. Gravitational potential
S. Pressure potential
List II: (Primary governing factors)
1. Solute concentration
2. Submergence depth
3. Capillarity and adsorptive forces
4. Elevation above a reference plane
(A) P-1, Q-3, R-4, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-1, R-3, S-2

2011
56. In the SPAC, at which interface does the highest resistance to liquid water flow typically occur under well-watered conditions?
(A) Soil to root epidermis
(B) Leaf mesophyll to substomatal cavity
(C) Root cortex to xylem
(D) Stomatal pore to atmosphere

2012
57. Which term describes the precipitation that flows down the trunks of trees and directly reaches the soil at the base?
(A) Throughfall
(B) Canopy drip
(C) Interception loss
(D) Stemflow

2013
58. The initial phase of infiltration into a dry soil is primarily governed by which dominant force?
(A) Matric suction gradient
(B) Gravitational head
(C) Osmotic gradient
(D) Hydrostatic pressure

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adsorptive forces of solids
(D) The potential energy associated with relative elevation in gravity field

2014

79. At permanent wilting point, the soil water is primarily held by which force?
(A) Capillary action of water retained within large macropores
(B) Osmotic forces from dissolved ions in the soil solution
(C) Gravitational pull directing downward drainage of free water
(D) Strong adhesion to soil particles as hygroscopic water

2023

80. Consider the following statements concerning the Soil-Plant-Atmosphere Continuum (SPAC):
I. Water moves from higher potential to lower potential.
II. Atmospheric water potential is generally higher than soil water potential.
III. The driving force is the vapor pressure deficit between the leaf and atmosphere.
IV. Xylem vessels provide a low-resistance pathway for water transport.
V. Stomatal closure decreases the resistance to water flow in SPAC.
Which of the above statements are correct?
(A) I, III, and IV
(B) II, III, and V
(C) I, II, and IV
(D) III, IV, and V

2011

81. Which precipitation partitioning component never reaches the soil surface and is lost entirely to the atmosphere?
(A) Stemflow water volume
(B) Canopy interception loss
(C) Throughfall precipitation
(D) Depression storage water

2013

82. Which empirical equation is commonly used to model the exponential decay of infiltration rate over time?
(A) Darcy's Law
(B) Manning's Equation
(C) Stokes' Law
(D) Horton's Equation

2015

83. The presence of swelling clays (like smectite) affects infiltration by causing which phenomenon upon wetting?
(A) Rapid decrease in infiltration rate due to pore sealing
(B) Immediate increase in macroporosity from soil shattering
(C) Neutral impact on total infiltration rate across the field
(D) Steady increase in basic infiltration rate over wet periods

2017

84. Which agronomic practice involves creating small, shallow depressions in the field to retain water and maximize infiltration?
(A) Subsoiling
(B) Puddling
(C) Tied ridging
(D) Planking

2025

85. Arrange the following runoff generation phases in the correct sequential order for a storm event:
I. Filling of depression storage
II. Rainfall begins
III. Infiltration capacity exceeded
IV. Surface runoff commences
Which of the above sequences is correct?
(A) II → I → III → IV
(B) II → III → I → IV
(C) I → II → III → IV
(D) II → I → IV → III

2015

86. Which parameter represents the total duration of runoff observed at the watershed outlet, from the rising limb to the end of the recession limb?
(A) Time to peak
(B) Lag time
(C) Time of concentration
(D) Base time

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2025

87. In the mechanics of water erosion, what is the primary role of overland flow (runoff)?
(A) Detachment of primary soil particles
(B) Transportation of detached soil particles
(C) Breakdown of soil aggregates
(D) Creation of splash craters

2025

88. In the Universal Soil Loss Equation ($A = RKLSCP$), which factor accounts for the effect of specific slope length and slope steepness?

2013
69. When harvested water is extremely limited, applying supplemental irrigation during which crop stage yields the highest water use efficiency?
(A) Active vegetative growth phase
(B) Critical moisture sensitive stage
(C) Early seedling emergence stage
(D) Post-maturity senescence stage

2012
70. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Micro-watershed planning is preferred over large river basin planning for implementing site-specific soil conservation measures.
Reason (R): Micro-watersheds allow for detailed participatory planning and address local geomorphological variations effectively.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2023
71. Which component is generally NOT a core part of integrated watershed management?
(A) Soil and water conservation
(B) Large-scale industrial urban planning
(C) Afforestation and pasture development
(D) Livelihood security and community participation

2022
72. Which index is widely used to classify meteorological drought based on rainfall probability and temperature?
(A) Normalized Difference Vegetation Index (NDVI)
(B) Crop Water Stress Index (CWSI)
(C) Standardized Precipitation Index (SPI)
(D) Leaf Area Index (LAI)

2009
73. A contingent crop plan for a delayed monsoon typically involves substituting standard crops with crops characterized by which trait?
(A) Deep rooting and long duration
(B) High water requirement and tillering capacity
(C) Frost tolerance
(D) Photo-insensitivity and short duration

2007
74. Which of the following is considered a mechanical mid-season correction to manage drought stress?
(A) Removal of lower mature leaves via leaf stripping
(B) Foliar spray of diluted liquid nitrogenous urea
(C) Spraying of chemical growth retardant like Cycocel
(D) Priming of crop seeds with water before field sowing

2018
75. Match the anti-transpirant chemicals with their primary mode of action:
List I: (Anti-transpirant chemicals)
P. Kaolin
Q. PMA (Phenyl mercuric acetate)
R. Mobileaf
S. Cycocel
List II: (Primary mode of action)
1. Stomata closing type
2. Growth retardant
3. Reflectant type
4. Film forming type
(A) P-1, Q-4, R-3, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-4, R-1, S-2

2005
76. Which soil physical parameter is determined by dividing the mass of oven-dry soil by its total (bulk) volume, including pores?
(A) Particle density
(B) Bulk density
(C) Soil porosity
(D) Specific gravity

2021
77. In the catchment water balance, if precipitation is 800 mm, evaporation is 400 mm, and runoff is 300 mm, what is the change in storage (ΔS)?
(A) +100 mm
(B) -100 mm
(C) +500 mm
(D) 0 mm

2022
78. Which of the following best defines soil matric potential?
(A) The pressure exerted by overlaying water under saturated soil conditions
(B) The reduction in potential due to dissolved salts in bulk soil solution
(C) The reduction in energy due to capillary and

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reservoirs
(C) Severe crop failure triggered by extreme moisture stress
(D) Total unavailability of green fodder for village livestock

2016
98. A contingent crop plan for an aberrant weather situation is fundamentally characterized by its:
(A) Structural rigidity and long-term fixed cropping plans
(B) Exclusive reliance on major canal irrigation projects
(C) Absolute avoidance of synthetic chemical fertilizers
(D) Built-in flexibility and readiness for alternate crops

2022
99. Which practice is categorized as a mid-season agronomic correction when a dry spell occurs 40 days after sowing a rainfed crop?
(A) Thinning every third row to lower plant population density
(B) Applying pre-emergence herbicide to control weed species
(C) Deep plowing the entire field to break subsurface hardpans
(D) Sowing a completely different short-duration crop variety

2001
100. Consider the following statements concerning anti-transpirants:
I. Cycocel (CCC) reduces vegetative growth and increases root-to-shoot ratio.
II. Kaolin acts as a reflectant, reducing leaf temperature and transpiration.
III. PMA is completely safe for human consumption and widely used on food crops.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) II

2021
101. Which term describes the ratio of the volume of voids to the total volume of a soil mass?
(A) Porosity
(B) Void ratio
(C) Bulk density
(D) Air capacity

2017
102. Which parameter is NOT typically a component of the catchment water balance equation?
(A) Precipitation
(B) Evapotranspiration
(C) Runoff
(D) Geothermal heat flux

2007
103. In saturated soils, which potential component is strictly zero?
(A) Gravitational potential
(B) Matric potential
(C) Pressure potential
(D) Osmotic potential

2009
104. Which soil texture generally holds the highest maximum volume of plant-available water?
(A) Sand
(B) Heavy clay
(C) Silt loam
(D) Loamy sand

2025
105. Consider the following statements regarding the SPAC (Soil-Plant-Atmosphere Continuum):
I. Water uptake is an entirely passive process driven by transpiration.
II. Resistance to water flow is highest in the xylem vessels.
III. Stomata regulate water loss by responding to environmental cues.
IV. Cavitation interrupts the continuous water column in the plant.
Which of the above statements are incorrect?
(A) I and III
(B) II only
(C) I and IV
(D) III and IV

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2022
106. Depression storage on the soil surface is immediately depleted by which two processes?
(A) Infiltration and evaporation
(B) Runoff and interception
(C) Transpiration and percolation
(D) Runoff and deep drainage

2003
107. When measuring infiltration with a double-ring infiltrometer, the infiltration rate is derived from:
(A) The drop in water level in the outer ring only
(B) The drop in water level in the inner ring only
(C) The combined drop in both rings

(A) P factor
(B) K factor
(C) LS factor
(D) C factor

2025
89. Which biological conservation measure utilizes residues of the previous crop left on the soil surface to protect against erosive rainfall?
(A) Cover cropping with dense winter legumes
(B) Strip cropping using erosion-resistant grass
(C) Contour farming along defined grade lines
(D) Conservation tillage and stubble mulching

2019
90. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Contour bunding is highly recommended for black cotton soils (Vertisols) in high rainfall regions.
Reason (R): Vertisols in high rainfall areas require drainage of excess water to prevent waterlogging.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2006
91. In alley cropping, what is the primary purpose of regularly pruning the hedgerow trees?
(A) To harvest timber for commercial firewood sales
(B) To reduce shading on the intercropped food plants
(C) To increase the vertical root depth of hedge trees
(D) To induce early flowering and seed setting phases

2012
92. Which ex-situ rainwater harvesting structure is specifically constructed across drainage lines to hold water long enough to allow it to seep into the ground?
(A) Farm pond
(B) Percolation tank
(C) Nala bund
(D) Stop dam

2021
93. When utilizing harvested water for life-saving irrigation in wheat, which growth stage is generally the most critical to avoid severe yield penalty?
(A) Crown Root Initiation (CRI)
(B) Late tillering
(C) Dough stage
(D) Maturity

2008
94. According to the hydrologic coding system, a watershed is geographically delineated based on which primary physical feature?
(A) Administrative and regional political boundaries
(B) Isohyetal lines representing equal rainfall depths
(C) Topographic ridgelines defining drainage divides
(D) Groundwater contours representing aquifer boundaries

2013
95. Match the watershed management terms with their definitions:
List I: (Watershed management terms)
P. Catchment area
Q. Drainage divide
R. Outlet
S. Time of concentration
List II: (Definitions)
1. The lowest point where all runoff exits
2. Total area draining into a common point
3. Time required for water from the most remote point to reach the outlet
4. Topographical ridge separating two watersheds
(A) P-4, Q-2, R-3, S-1
(B) P-2, Q-1, R-4, S-3
(C) P-1, Q-4, R-2, S-3
(D) P-2, Q-4, R-1, S-3

2019
96. Which participatory rural appraisal (PRA) tool relies on mapping historical changes in natural resources and village layout?
(A) Wealth ranking of community households
(B) Seasonal calendar of agricultural tasks
(C) Time line and historical transect maps
(D) Venn diagram of institutional relations

2017
97. Hydrological drought is primarily characterized by which of the following indicators?
(A) Sub-normal rainfall occurring over three consecutive weeks
(B) Depletion of surface water and groundwater

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2016
59. Which topographical factor reduces the opportunity time for infiltration during a high-intensity rainfall event?
(A) High vegetation cover
(B) Steep land slope
(C) Depressional storage
(D) Contour farming

2022
60. Consider the following statements concerning soil amendments and infiltration:
I. Addition of organic matter improves soil aggregation, thereby increasing infiltration.
II. Deep tillage creates macropores that permanently increase basic infiltration rates.
III. Synthetic soil conditioners like PAM stabilize soil structure and maintain infiltrability.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) III

2019
61. In the SCS Curve Number method, a Curve Number (CN) of 100 indicates what condition regarding the catchment surface?
(A) Completely impermeable surface like urban concrete
(B) Highly permeable sandy soil with fast infiltration
(C) Dense forest cover with very high initial abstraction
(D) Dry antecedent moisture condition in agricultural field

2013
62. Which hydrologic index represents the average rainfall intensity above which the volume of rainfall equals the volume of direct runoff?
(A) Phi-index
(B) W-index
(C) Horton's index
(D) Runoff coefficient

2018
63. Identify the final, most severe stage of water erosion characterized by deep, wide channels that cannot be obliterated by ordinary tillage implements.
(A) Rill erosion
(B) Sheet erosion
(C) Gully erosion
(D) Ravine erosion

2010
64. In the USLE, what specific unit does the calculated 'A' value represent?
(A) Millimeters of topsoil lost per year
(B) Cubic meters of sediment yield per catchment
(C) Tons of soil lost per hectare per year
(D) Percentage of arable land degraded

2002
65. Consider the following statements regarding biological soil-water conservation measures:
I. Cover crops provide continuous soil protection during high rainfall periods.
II. Contour farming involves ploughing up and down the slope.
III. Strip cropping balances the income from row crops with the conservation benefits of dense crops.
IV. Mulching increases soil temperature extremes.
Which of the above statements are incorrect?
(A) I and III
(B) II and IV
(C) I, II, and III
(D) II, III, and IV

2001
66. For slopes exceeding 16% in hilly regions with deep soils, which mechanical conservation measure is most scientifically recommended?
(A) Graded bunding
(B) Contour trenching
(C) Broad bed and furrow
(D) Bench terracing

2023
67. Which property of Vetiver grass (Vetiveria zizanioides) makes it exceptionally suitable as a vegetative barrier for soil conservation?
(A) Deep, extensive, and massive root network
(B) Shallow, spreading root system
(C) High susceptibility to waterlogging
(D) Rapid lateral spread via rhizomes into agricultural fields

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2015
68. What is the fundamental purpose of constructing a check dam across a first-order stream in a watershed?
(A) To generate hydroelectric power
(B) To provide deep water navigation
(C) To arrest soil erosion and recharge groundwater
(D) To divert the entire stream flow out of the catchment

(D) The overflow from the outer ring

2018

108. How does the presence of a shallow water table affect the infiltration process?
(A) It continuously increases the basic infiltration rate over time
(B) It causes infiltration to cease upon complete profile saturation
(C) It significantly increases the initial sorptivity of dry soil
(D) It restricts horizontal and lateral subsurface water flow only

2012

109. Which amendment physically disrupts the soil surface crust to enhance infiltrability without the addition of chemicals?
(A) Hoed inter-cultivation
(B) Broadcasting gypsum
(C) Spreading urea
(D) Applying farmyard manure

2001

110. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): The Rational formula is best suited for estimating peak runoff in very large river basins (e.g., $> 10{,}000$ sq km).
Reason (R): The Rational formula assumes uniform rainfall intensity over the entire catchment duration.
Based on these statements, select the correct option:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

111. Which factor predominantly dictates the shape of the rising limb of a stream hydrograph?
(A) Baseflow characteristics
(B) Groundwater release rate
(C) Deep aquifer transmissivity
(D) Rainfall intensity and duration

2001

112. Rill erosion is defined by the presence of:
(A) Deep U-shaped channels impossible to cross with machinery
(B) Large chasms forming ravines
(C) Micro-channels that can be erased by normal tillage
(D) Uniform scraping of the topsoil

2015

113. In the USLE, the P factor (Support Practice Factor) accounts for the erosion-reducing effects of which practices?
(A) Vegetative mulching and systematic crop rotations
(B) Contour farming, strip cropping, and terracing
(C) Soil texture, structure, and organic matter content
(D) Rainfall intensity, energy, and storm duration

2021

114. How does a cover crop primarily minimize soil detachment?
(A) By physically increasing the field's effective slope length
(B) By systematically increasing the subsurface soil bulk density
(C) By significantly accelerating the downslope runoff velocity
(D) By absorbing and breaking the kinetic energy of raindrops

2012

115. Select the correct sequence of mechanical conservation measures from lowest slope gradient to highest slope gradient suitability:
(A) Contour bunding → Graded bunding → Bench terracing
(B) Bench terracing → Graded bunding → Contour bunding
(C) Graded bunding → Contour bunding → Bench terracing
(D) Contour bunding → Bench terracing → Graded bunding

2011

116. Vegetative barriers in agroforestry systems trap sediment primarily by:
(A) Emitting organic chemical exudates that flocculate soil particles
(B) Absorbing and transpirating all surface runoff through root uptake
(C) Reducing overland runoff velocity as a dense physical filter
(D) Chemically altering the localized rainfall erosivity index

2001

117. What is a defining feature of a semi-circular bund in rainwater harvesting?
(A) A half-moon earthen bund to capture runoff

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2010

155. Match the terms related to the SPAC in List I with their descriptions in List II:

List I: (SPAC Terms)

P. Cohesion
Q. Adhesion
R. Transpiration
S. Root pressure

List II: (Descriptions)

1. Attraction between water molecules and cell walls
2. Loss of water vapor from stomata
3. Attraction between water molecules themselves
4. Positive pressure generated in the xylem

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-1, Q-4, R-2, S-3

2019

156. Throughfall is defined as precipitation that:
(A) is absorbed directly by the upper leaves
(B) passes through the canopy to the ground
(C) runs down the main stem of the plant
(D) evaporates before reaching the canopy

2007

157. Which parameter dictates the shape of the cumulative infiltration curve during the initial few minutes of a rainfall event?
(A) Soil sorptivity
(B) Saturated hydraulic conductivity
(C) Aquifer transmissivity
(D) Surface roughness

2012

158. The infiltration rate of a crusted soil can be most rapidly improved by:
(A) Systematically applying nitrogen-based fertilizers
(B) Mechanically rolling and compacting the topsoil layer
(C) Mechanically breaking the surface crust via hoeing
(D) Applying a selective pre-emergence chemical herbicide

2017

159. Agronomic practices like zero-tillage with residue retention improve infiltration primarily by:
(A) Pulverizing the topsoil into fine dust particles
(B) Eliminating critical subterranean earthworm populations
(C) Creating a compacted subsurface agricultural hardpan
(D) Protecting surface aggregates and enhancing biopores

2011

160. Consider the following statements regarding runoff mechanisms:
I. Runoff only occurs when the soil is fully saturated to the surface.
II. Hortonian runoff is common in arid regions with crusted soils.
III. Dense vegetation delays the time of concentration of runoff.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2001

161. A hydrograph plots which two variables against each other?
(A) Rainfall depth vs. Runoff depth
(B) Discharge rate vs. Time
(C) Infiltration rate vs. Time
(D) Evaporation vs. Soil moisture

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2015

162. Splash erosion contributes to runoff generation by:
(A) Digging deep, structural gully networks across the field
(B) Systematically increasing the physical slope steepness of the land
(C) Removing the entire topsoil A horizon during a single storm event
(D) Clogging soil macropores with fine particles to seal the surface

2006

163. In the USLE, which factor cannot be modified by human intervention to reduce soil loss?
(A) R factor
(B) C factor
(C) P factor
(D) LS factor (to some extent via terracing)

2018

164. Which of the following is an erosion-permitting crop, typically requiring strip cropping with a legume for soil conservation?
(A) Cowpea planted as a dense cover
(B) Groundnut acting as a close-growing crop
(C) Sorghum planted in wide, open rows
(D) Blackgram cultivated as a conservation crop

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(B) Extremely rapid internal drainage and percolation
(C) Reduced hydraulic conductivity from lower macroporosity
(D) Increased upward capillary rise to the soil surface

2008

127. Which variable in the water balance equation is generally estimated using lysimeters?
(A) Surface runoff
(B) Precipitation
(C) Deep percolation
(D) Evapotranspiration

2007

128. What happens to the soil water potential as the soil dries from Field Capacity to Permanent Wilting Point?
(A) It becomes more positive
(B) It remains constant
(C) It becomes increasingly negative
(D) It approaches zero

2012

129. At standard atmospheric pressure, the matric potential of a completely saturated soil is:
(A) Positive
(B) Zero
(C) -15 bars
(D) -0.3 bars

2022

130. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): The driving force for transpiration in the SPAC is the gradient in water vapor pressure between the sub-stomatal cavity and the bulk atmosphere.
Reason (R): Water moves from a region of higher vapor pressure (inside the leaf) to a lower vapor pressure (atmosphere).
Based on these statements, select the correct option:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

131. Which term defines the volume of water retained on leaves and stems that subsequently evaporates without adding to soil moisture?
(A) Interception loss
(B) Net precipitation
(C) Stemflow
(D) Throughfall

2018

132. During an intense rainstorm, infiltration rate initially drops rapidly and then approaches a constant value. This constant value is closely related to the soil's:
(A) Total volumetric porosity
(B) Soil water field capacity
(C) Saturated hydraulic conductivity
(D) Hygroscopic water coefficient

2008

133. Which environmental factor can temporarily increase the apparent infiltration rate of a frozen soil upon thawing?
(A) Freeze-thaw cycles inducing soil aggregation and cracking
(B) Increased water viscosity slowing down internal drainage
(C) Decreased matric suction gradient in the lower profile
(D) Sub-zero soil temperatures freezing the capillary pores

NODIA

2008

134. Addition of polyacrylamide (PAM) to irrigation water prevents runoff primarily by:
(A) Significantly increasing irrigation water viscosity
(B) Creating a thin, temporary waterproof surface crust
(C) Chemically dissolving high-density soil minerals
(D) Stabilizing surface soil aggregates against dispersion

2023

135. **List I: (USLE Factors)**
P. R factor
Q. K factor
R. LS factor
S. C factor
List II: (Measurement units/basis)
1. Dimensionless ratio relative to clean-tilled fallow
2. Dimensionless ratio based on plot length and steepness
3. Tons per hectare per unit of erosivity
4. Megajoule millimeter per hectare per hour per year
(A) P-4, Q-3, R-2, S-1

(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

2007

136. Runoff generation by the 'saturation excess' (Hewlett) mechanism implies that runoff occurs when:
(A) Downward rainfall intensity exceeds soil infiltration capacity
(B) Soil infiltration capacity becomes zero due to surface paving
(C) The soil profile becomes completely saturated from below upward
(D) The contributing catchment topography remains perfectly flat

2008

137. Which phase of water erosion is often completely unnoticed by farmers until topsoil fertility severely declines?
(A) Gully erosion
(B) Ravine formation
(C) Rill erosion
(D) Sheet erosion

2022

138. Which practice relies on modifying the micro-topography of the soil surface to capture and infiltrate runoff in-situ?
(A) Broad Bed and Furrow (BBF)
(B) Continuous intensive tillage
(C) Stubble burning
(D) Subsoiling without surface modification

2022

139. How does contour farming inherently reduce soil erosion?
(A) By creating furrows that run downhill to drain water quickly
(B) By creating miniature reservoirs across the slope to impound water
(C) By significantly increasing the field's effective slope steepness
(D) By systematically compacting the topsoil surface layer

2015

140. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Graded bunding is preferred over contour bunding in areas with annual rainfall exceeding 600 mm and highly clayey soils.
Reason (R): Graded bunds safely dispose of excess runoff to prevent crop damage from prolonged waterlogging.
Based on these statements, select the correct option:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

141. The primary function of a vegetative filter strip placed at the lower edge of an agricultural field is to:
(A) Induce deposition of suspended sediment
(B) Systematically increase surface runoff volume
(C) Rapidly evaporate accumulated surface water
(D) Biologically fix excess atmospheric nitrogen

2002

142. A percolation tank is typically sited on highly permeable soils. Which geological feature is most desirable beneath the tank?
(A) A thick, completely impermeable swelling clay layer
(B) A massive, non-porous solid granite bedrock formation
(C) Weathered, fractured, or porous strata linked to an aquifer
(D) A highly localized shallow perched groundwater table

2010

143. Which technique is used to line the bottom of a farm pond to drastically reduce seepage losses in porous soils?
(A) Deep structural addition of coarse gravel
(B) Systematic planting of deep-rooted grasses
(C) Spraying chemical cetyl alcohol solutions
(D) Application of bentonite clay or geomembranes

2014

144. In a mini-watershed spanning 500 to 1000 hectares, what is typically the highest stream order expected?
(A) First order
(B) Second or third order
(C) Sixth order
(D) Tenth order

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2014

145. Which objective is paramount in the upper reaches (ridge area) of a watershed management plan?
(A) Intensive structural irrigation development programs
(B) Soil and moisture conservation via vegetative cover
(C) Engineering construction of large masonry storage dams
(D) Systematic deep borewell drilling for groundwater

2013

146. A meteorological drought is usually declared by the Indian Meteorological Department when the seasonal rainfall deficiency exceeds what percentage of the long-term average?
(A) 5%
(B) 10%
(C) 19%
(D) 50%

2025

147. Under contingent planning, if a rainfed crop completely fails early in the season due to a severe dry spell, what is the standard recommended action?
(A) Plow the crop and sow a short-duration catch crop
(B) Continue irrigating the failing field with drinking water
(C) Apply heavy chemical doses of quick-release nitrogen
(D) Leave the degraded land completely fallow for two years

2019

148. Which mid-season correction involves cutting the crop just above the ground level to allow regrowth when favorable moisture returns?
(A) Thinning
(B) Mulching
(C) Ratooning
(D) Weed management

2024

149. Anti-transpirants are practically recommended for use in agriculture primarily under which condition?
(A) Saving crops from wilting during transient dry spells
(B) Maximizing total grain yields under full surface irrigation
(C) Accelerating active plant transpiration during winter months
(D) Promoting competitive weed growth inside the cropped area

NODIA

2012

150. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Reflectant anti-transpirants like kaolin increase the leaf albedo.
Reason (R): Increased albedo raises the leaf temperature, causing stomata to close.
Based on these statements, select the correct option:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

151. Which soil structure type is commonly found in compacted subsoils and severely impedes vertical water movement?
(A) Granular
(B) Platy
(C) Crumb
(D) Single grained

2022

152. In a closed catchment with no groundwater leakage, the difference between long-term precipitation and runoff is generally equal to:
(A) Interception
(B) Depression storage
(C) Evapotranspiration
(D) Infiltration

2015

153. Osmotic potential becomes the dominant force controlling water availability to plants in which type of soils?
(A) Acid sulfate soils
(B) Calcareous soils
(C) Lateritic soils
(D) Saline soils

2010

154. Which soil texture maintains the highest moisture content at the Permanent Wilting Point?
(A) Loamy sand
(B) Sandy loam
(C) Silt loam
(D) Clay

around trees
(B) A reinforced concrete wall spanning across perennial rivers
(C) A masonry structure requiring extensive steel reinforcement
(D) A gravity drainage channel designed to divert crop water

2019
118. Which irrigation method maximizes the water use efficiency of harvested rainwater for supplemental irrigation?
(A) Flooding
(B) Furrow irrigation
(C) Check basin irrigation
(D) Drip irrigation

2021
119. A 'watershed' is fundamentally a hydrological unit, but in integrated management, it is also treated as a:
(A) Purely administrative block
(B) Socio-ecological system
(C) Singular geological formation
(D) Closed economic zone

2001
120. Consider the following statements regarding Participatory Rural Appraisal (PRA) techniques:
I. PRA utilizes visual tools to facilitate participation by illiterate community members.
II. Matrix scoring is used to prioritize local problems.
III. PRA avoids the use of indigenous technical knowledge.
IV. Social mapping identifies households and social structures.
V. The outcome of PRA is a strictly rigid, unchanging master plan.
Which of the above statements are correct?
(A) I, II, and IV
(B) II, III, and V
(C) I, III, and V
(D) I, II, and III

2009
121. The occurrence of an agricultural drought is most directly linked to a deficit in:
(A) Deep groundwater table elevation and aquifer storage
(B) Surface river discharge volume and reservoir levels
(C) Cumulative annual monsoon aggregate rainfall depth
(D) Soil moisture availability during critical crop growth

2006
122. Under contingent crop planning, if the monsoon is delayed beyond mid-August in central India, farmers are typically advised to sow:
(A) Pearl millet or short-duration mungbean
(B) Long-duration pigeonpea or full-season cotton
(C) Water-intensive sugarcane or perennial orchards
(D) Irrigated winter wheat or deep-rooted mustard

2006
123. The agronomic practice of 'weed management' during a mid-season dry spell acts as a moisture conservation strategy by:
(A) Increasing regional surface albedo and solar reflection
(B) Removing weed competition for limited soil moisture
(C) Increasing active crop canopy interception of rainfall
(D) Significantly lowering surface soil temperature profiles

2014
124. How do osmoregulators like proline and glycine betaine assist plants during moisture stress?
(A) Coating the leaf surface with wax to block stomata
(B) Lowering cellular osmotic potential to maintain turgor
(C) Reflecting excess solar radiation from the leaf canopy
(D) Accelerating senescent leaf drop to conserve plant water

2005
125. Arrange the following soil particles in order of increasing water retention capacity per unit mass:
I. Coarse sand
II. Silt
III. Clay
(A) I → II → III
(B) III → II → I
(C) I → III → II
(D) II → I → III

2025
126. A soil with a high bulk density generally exhibits which characteristic regarding water movement?
(A) Significantly increased water infiltration rate

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2001
165. The construction of bench terraces is typically limited by which soil parameter?
(A) Topsoil depth sufficient to prevent bedrock exposure
(B) Soil color characteristics indicating high organic matter
(C) Soil pH values ranging from highly acidic to strongly alkaline
(D) Carbon-to-nitrogen ratio influencing biological activity

2009
166. In an agroforestry system designed for soil conservation on slopes, tree rows should ideally be aligned:
(A) Up and down the slope
(B) In a random scatter
(C) Only at the ridge top
(D) Along the contour lines

2017
167. Which structure is a traditional, localized rainwater harvesting system used in the arid regions of Rajasthan, consisting of a covered underground tank?
(A) Khadin
(B) Tanka
(C) Zabo
(D) Ahar

2023
168. Supplemental irrigation using harvested water during the reproductive stage of pulses prevents which detrimental phenomenon?
(A) Excessive vegetative growth
(B) Weed proliferation
(C) Flower and pod drop
(D) Early germination

2003
169. What is the fundamental unit of planning and execution in India's Integrated Watershed Management Programme (IWMP)?
(A) The River Basin
(B) The District
(C) The Agro-climatic zone
(D) The Micro-watershed

2025
170. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Participatory Rural Appraisal (PRA) requires the active involvement of local women and marginalized groups.
Reason (R): Inclusive participation ensures that watershed interventions address diverse livelihood needs and ensure equitable resource distribution.
Based on these statements, select the correct option:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009
171. A drought year is defined by the IMD when the area affected by moderate to severe drought exceeds what percentage of the country's total area?
(A) 10%
(B) 20%
(C) 40%
(D) 50%

2004
172. Which agronomic measure minimizes evaporation losses from the soil surface during a prolonged dry spell?
(A) Surface broadcasting of chemical fertilizers
(B) Application of organic mulch crop residues
(C) Continuous deep plowing before the rainy season
(D) Frequent light sprinkler irrigation applications

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2014
173. What is the primary purpose of 'dust mulching' via shallow hoeing during a dry spell?
(A) To break capillary continuity and reduce evaporation
(B) To systematically add essential nutrients to the topsoil
(C) To significantly increase the subsurface soil bulk density
(D) To promote rapid germination of dormant weed seeds in-situ

2018
174. Hexadecanol is utilized in agriculture and water management primarily to:
(A) Eradicate aggressive aquatic weeds in large surface reservoirs
(B) Enhance biological root nodulation in summer legume crops
(C) Form a monomolecular film on water to retard evaporation

(D) Defoliate mature cotton plants before automated mechanical harvest

2016

175. **List I: (Soil Moisture Concepts)**

P. Field Capacity
Q. Gravitational Water
R. Capillary Water
S. Hygroscopic Water

List II: (Definitions)

1. Water held tightly to soil particles, unavailable to plants
2. Water held in micropores, available to plants
3. Water draining freely under gravity
4. Moisture content after free drainage ceases

(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-4, R-2, S-3

2013

176. Which soil physical property is least affected by conventional tillage operations?
(A) Bulk density
(B) Total porosity
(C) Soil texture
(D) Soil structure

2008

177. If a catchment has an area of 10 hectares and receives 100 mm of uniform rainfall, what is the total volume of precipitation received in cubic meters?
(A) 1,000 cubic meters
(B) 10,000 cubic meters
(C) 100,000 cubic meters
(D) 1,000,000 cubic meters

2025

178. What is the primary difference between matric potential and pressure potential in a soil profile?
(A) Matric potential is active in saturated zones, while pressure potential dominates unsaturated conditions
(B) Matric potential is governed strictly by chemical salts, while pressure potential is driven by gravity
(C) There is no physical difference between the two concepts as they are completely synonymous variables
(D) Matric potential is negative (suction), whereas pressure potential is positive (submergence)

2013

179. Readily Available Water (RAW) is generally considered to be what fraction of the Total Available Water Capacity (AWC)?
(A) The upper 10-25%
(B) The upper 50-75%
(C) The lower 10-25%
(D) Exactly 100%

2019

180. Consider the following statements concerning the soil-plant-atmosphere continuum (SPAC) mechanism:

I. Xylem cavitation severely disrupts the SPAC.
II. Leaf water potential must be lower than root water potential for upward flow.
III. Soil water potential has no influence on transpiration rate.

Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I

2001

181. Which component of the precipitation partitioning process is most directly influenced by the Leaf Area Index (LAI) of a forest?
(A) Canopy interception
(B) Infiltration
(C) Baseflow
(D) Deep percolation

2007

182. During the first few minutes of a storm on dry soil, the infiltration rate is high due to a steep gradient in which potential?
(A) Gravitational potential
(B) Osmotic potential
(C) Pressure potential
(D) Matric potential

2012

183. Which of the following conditions yields the highest final basic infiltration rate?
(A) A compacted clay loam
(B) A sandy soil under pasture
(C) A bare crusted silt loam
(D) A waterlogged peat soil

2025

184. The addition of biochar to degraded soils generally improves water retention by:
(A) Significantly increasing the overall bulk density of the soil profile

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(B) Creating a strongly hydrophobic surface layer that repels water
(C) Adding highly porous carbon structures to increase total porosity
(D) Completely replacing functional clay mineral particles in the matrix

2002
185. In the Rational Method formula ($Q = \frac{CIA}{360}$), what units are typically used for Intensity (I) and Area (A) to yield Discharge (Q) in cubic meters per second?
(A) I in cm/hr, A in hectares
(B) I in mm/day, A in sq km
(C) I in m/s, A in sq meters
(D) I in mm/hr, A in hectares

2009
186. Which parameter causes the recession limb of a hydrograph to tail off slowly rather than dropping instantly after rainfall stops?
(A) Subsurface return flow and baseflow
(B) Dense foliage canopy interception
(C) Surface depression water storage
(D) Rapid downslope surface runoff

2022
187. Which process determines the soil detachment capacity of rainfall?
(A) Infiltration capacity of the soil
(B) Terminal velocity and mass of raindrops
(C) Subsurface drainage rate
(D) Soil pH

2014
188. In the USLE, a C-factor of 1.0 indicates what field condition?
(A) Undisturbed dense forest cover with thick litter layer
(B) Continuous bare fallow with up-and-down slope tillage
(C) Well-managed permanent pasture with complete ground cover
(D) No-till farming systems with 100% residue conservation

2023
189. Mulching affects the microclimate and soil-water balance by:
(A) Decreasing surface runoff and evaporation
(B) Increasing diurnal soil temperature fluctuations
(C) Enhancing weed growth
(D) Reducing infiltration

2024
190. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Contour trenching is an effective soil-water conservation measure for afforestation on highly degraded, non-arable hill slopes.
Reason (R): Trenches break the slope length, intercept runoff, and provide localized moisture for tree seedlings.
Based on these statements, select the correct option:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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2016
191. Grassed waterways in an agricultural watershed are primarily designed to:
(A) Store large volumes of drinking water for grazing livestock
(B) Cultivate commercial aquatic cash crops in stagnant water
(C) Promote rapid vertical infiltration of all surface overland flow
(D) Safely conduct excess runoff away without causing gully erosion

2015
192. Farm ponds in vertisols (black soils) typically do not require synthetic lining because:
(A) Total atmospheric evaporation is virtually zero in these clay soils
(B) Water is stored entirely above ground in elevated storage structures
(C) Swelling clays naturally seal the pond bottom to minimize seepage
(D) They are designed to be used exclusively during active monsoon months

2024
193. The primary constraint to utilizing harvested rainwater for irrigation in arid regions is:
(A) The very high sediment load clogging irrigation pipes
(B) High evaporation and seepage losses limiting storage duration
(C) The extreme cold temperatures of the water
(D) High cost of pumping relative to the value of crops

2018

194. Which stream ordering system, where two streams of order 'n' join to form a stream of order '$n+1$', is standardly used in watershed geomorphology?
(A) Rational system
(B) Curve Number system
(C) Penman-Monteith system
(D) Horton-Strahler system

2011

195. **List I: (PRA Tools)**
P. Resource Map
Q. Seasonal Calendar
R. Venn Diagram
S. Transect Walk
List II: (Objectives)
1. Analyze weather, labor, and cropping patterns across the year
2. Identify spatial distribution of land, water, and forests
3. Understand institutional relationships and influence
4. Direct observation of spatial variability and topography
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-4, R-1, S-3

2019

196. An agricultural drought occurs specifically when:
(A) The river levels and reservoir storage fall below fifty percent capacity
(B) The municipal urban water supply is strictly rationed for domestic use
(C) Soil moisture is insufficient to meet crop evapotranspiration demand
(D) The total annual rainfall is normal but concentrated within a single week

2002

197. Which resilient crop is commonly integrated into contingent plans for dryland areas due to its deep taproot and drought tolerance?
(A) Castor
(B) Paddy rice
(C) Sugarcane
(D) Jute

2024

198. During a mid-season drought, applying a foliar spray of 2% urea or KCl helps the crop by:
(A) Eradicating localized foliar fungal pathogens from the crop
(B) Closing stomatal pores permanently to prevent water loss
(C) Acting as a synthetic reflective barrier or liquid mulch
(D) Maintaining cellular turgor and promoting quick recovery

2015

199. Which mechanism explains how Cycocel (CCC) aids in drought mitigation?
(A) It forms a heavy physical wax barrier layer on the surface of active leaves
(B) It retards shoot growth while allowing root growth to limit transpiration
(C) It reflects incoming solar radiation to cool the temperature of crop leaves
(D) It actively pumps stored groundwater directly into the primary root system

2025

200. Consider the following statements concerning soil water retention:
I. Soil texture dictates the total internal surface area available for water retention.
II. Organic matter drastically reduces water retention capacity.
III. Soil compaction increases the volume of capillary pores relative to macropores.
IV. The permanent wilting point is higher in clay soils than in sandy soils.
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

2023

201. Which component is considered the 'output' in the catchment water balance equation?
(A) Precipitation
(B) Ground water recharge from adjacent basins
(C) Dew fall
(D) Evapotranspiration and Runoff

2001

202. What term refers to the energy status of soil water relative to pure, free water at standard pressure and elevation?
(A) Soil water potential
(B) Hydraulic conductivity
(C) Volumetric water content
(D) Dielectric constant

2001

203. Which constant is not a fixed physical property but rather an empirical concept dependent on drainage rate and crop rooting depth?
(A) Particle density

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(B) Field Capacity
(C) Saturation percentage
(D) Total porosity

2011

204. In the SPAC, what is the sequence of water potential gradients from highest (least negative) to lowest (most negative) under active transpiration?
(A) Soil > Root > Leaf > Atmosphere
(B) Atmosphere > Leaf > Root > Soil
(C) Root > Soil > Atmosphere > Leaf
(D) Leaf > Atmosphere > Soil > Root

2001

205. Which form of precipitation partitioning provides the most direct and localized input to soil moisture immediately at the base of a plant?
(A) Stemflow
(B) Canopy interception
(C) Throughfall
(D) Depression storage

2012

206. A double-ring infiltrometer measures a constant infiltration rate of 15 mm/hr after 3 hours. This rate is strictly termed the:
(A) Cumulative infiltration
(B) Initial infiltration rate
(C) Basic infiltration rate
(D) Sorptivity

2014

207. The presence of a highly compacted plow pan immediately below the tilled layer has what effect on infiltration?
(A) It causes extremely rapid deep percolation into the underlying aquifers
(B) It significantly increases the final basic soil infiltration rate
(C) It completely eliminates any functional need for surface field drainage
(D) It severely restricts downward water movement, causing early ponding

2005

208. Which soil amendment improves infiltrability by displacing sodium ions and promoting flocculation of clay particles?
(A) Urea
(B) Rock phosphate
(C) Gypsum
(D) Potassium chloride

2010

209. In the SCS Curve Number method, a catchment characterized by highly degraded pasture on heavy clay soil will have:
(A) A very low Curve Number (e.g., 30)
(B) A high Curve Number (e.g., 85)
(C) A Curve Number of zero
(D) A negative Curve Number

2011

210. Which basic hydrograph parameter represents the highest discharge rate achieved during a specific storm event?
(A) Baseflow
(B) Time to peak
(C) Recession constant
(D) Peak flow

****

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63. (C) Gully erosion
Gully erosion represents the advanced stage of water erosion. It occurs when concentrated runoff cuts deep, wide channels into the land surface. These channels are too large to be crossed or smoothed over by standard agricultural tillage machinery, leading to severe land fragmentation and irreversible loss of fertile soil.

64. (C) Tons of soil lost per hectare per year
The Universal Soil Loss Equation is designed to predict long-term average annual soil loss from specific fields. The calculated output value represents the estimated quantity of soil removed by erosion, expressed in units of tons of soil lost per hectare of land per year, helping guide conservation planning.

65. (B) II and IV
Contour farming requires cultivating along the contours of the land, not up and down slopes. Additionally, mulching buffers soil temperatures rather than increasing temperature extremes. Because statements two and four contain incorrect factual assertions about these biological conservation methods, they are the correct choice for this question.

66. (D) Bench terracing
For steep slopes ranging from sixteen to thirty-three percent, standard bunding is ineffective and can fail structurally. Bench terracing is recommended for deep soils on these slopes. It reshapes the hill into a series of level steps, reducing runoff velocity, preventing soil erosion, and enabling safe agricultural cultivation.

67. (A) Deep, extensive, and massive root network
Vetiver grass is widely used for biological soil conservation because it develops a dense, massive, and deep root system that can penetrate several meters into the soil. This root network acts like an underground anchor that stabilizes the soil profile, while the stiff stems filter sediment from runoff.

68. (C) To arrest soil erosion and recharge groundwater
Check dams are small barrier structures built across drainage channels. Their primary hydrological function is to reduce the velocity of flowing water, which prevents gully bed erosion and traps sediment. By holding water temporarily, they also increase the opportunity time for localized infiltration, facilitating effective groundwater recharge.

69. (B) Critical moisture sensitive stage
When harvested water reserves are highly limited, applying irrigation during critical moisture-sensitive stages, such as flowering or grain initiation, yields the highest response. Water stress during these specific phases causes irreversible damage to crop yields, making targeted supplemental irrigation highly efficient for maintaining overall crop productivity.

70. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Micro-watershed planning is highly effective because it focuses on a manageable scale where local communities can actively participate. This localized approach allows planners to address specific geomorphological variations, soil types, and farming systems. Therefore, both the assertion and the reason are true, and the reason correctly explains the assertion.

71. (B) Large-scale industrial urban planning
Integrated watershed management focuses on sustainable natural resource management within a hydrological boundary. Core activities include soil and water conservation, afforestation, pasture management, and promoting community livelihoods. Large-scale industrial urban planning falls outside this scope, as it does not target agricultural, ecological, or rural land rehabilitation.

72. (C) Standardized Precipitation Index (SPI))
The Standardized Precipitation Index is a widely accepted tool for monitoring meteorological drought. It is calculated by fitting historical rainfall data to a probability distribution, allowing researchers to quantify precipitation deficits over multiple timescales. This index helps characterize drought severity and compare dry conditions across diverse climatic regions.

73. (D) Photo-insensitivity and short duration
When the monsoon onset is delayed, the remaining growing season is significantly shortened. A successful contingent crop plan must utilize alternative varieties characterized by photo-insensitivity and short duration. These traits ensure that the crop can mature quickly and produce stable yields before the onset of winter temperature drops and moisture stress.

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generate less runoff. Conversely, higher curve numbers represent impermeable surfaces or low-infiltration soils that produce greater runoff. Therefore, the assertion is incorrect because high-infiltration soils have lower curve numbers, while the reason is correct.

11. (B) Recession limb
The recession limb of a hydrograph represents the declining portion of streamflow after the peak discharge has occurred. This phase illustrates the gradual withdrawal and depletion of water from temporary storage areas within the catchment, including surface depressions, channel networks, and shallow subsurface zones, after active rainfall has completely ceased.

12. (B) Sheet erosion
Sheet erosion is the progressive, uniform removal of thin layers of fertile topsoil from the land surface. It is initiated by raindrop impact and overland flow across wide areas. Because this process occurs evenly across the field without forming distinctive channels or gullies, it often remains undetected by farmers until significant productivity is lost.

13. (A) Crop management factor
The crop management factor in the soil loss equation reflects the combined influence of vegetation cover, crop rotations, and tillage practices on soil erosion. It compares soil loss from land under specific cropping systems to clean-tilled continuous fallow, helping plan effective biological conservation measures to minimize agricultural soil degradation.

14. (C) Strip cropping
Strip cropping is a biological conservation practice where erosion-permitting row crops are grown in alternating bands with erosion-resisting close-growing crops along the contour. The dense vegetation strips intercept runoff, reduce its flow velocity, and trap suspended sediment particles, thereby preventing water erosion and maximizing moisture conservation across sloping agricultural fields.

15. (D) P-3, Q-1, R-2, S-4
Mechanical measures are tailored to specific slopes and rainfall conditions. Contour bunds suit slopes up to six percent in low rainfall areas to conserve moisture. Graded bunds work in high rainfall areas to safely drain water. Bench terracing is designed for steep slopes, while trenching is ideal for non-agricultural hilly wastelands.

16. (C) Contour hedge planting
Contour hedge planting involves establishing narrow, continuous bands of perennial shrubs or woody species along the natural contours of sloping lands. These living barriers physically intercept downslope runoff, reduce water velocity, and promote sediment deposition. This process gradually forms natural terraces and significantly enhances in-situ soil moisture conservation.

17. (B) Farm ponds store surface water for direct utilization, whereas percolation tanks facilitate groundwater recharge
Farm ponds are constructed to harvest and store surface runoff locally, allowing for direct agricultural use such as supplemental or life-saving irrigation. In contrast, percolation tanks are specifically designed to retain water and facilitate its downward movement through the soil profile, primarily aiming to recharge the underlying unconfined aquifers.

18. (C) Anthesis and grain filling initiation
The flowering, anthesis, and early grain filling stages represent the physiological peak of water demand in cereal crops. Water stress during these critical growth phases severely impairs pollination, reduces grain setting, and limits carbohydrate translocation. Applying supplemental irrigation at this time ensures maximum water use efficiency and prevents substantial yield loss.

19. (C) 500 to 1000 hectares
In India, watershed classification is based on geographical area to streamline planning and execution. A micro-watershed represents a highly localized hydrological unit with an area ranging from five hundred to one thousand hectares. This small size makes it highly suitable for community-based participatory planning and targeted soil conservation interventions.

20. (B) II and III
Participatory Rural Appraisal utilizes a bottom-up approach rather than top-down government engineering. Resource mapping is a fundamental tool that allows communities to visualize their local assets and spatial layout. This process empowers residents to actively identify their

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developmental problems and design sustainable, site-specific solutions for local watershed management.

21. (A) Meteorological drought
Meteorological drought is defined strictly by the degree of dryness and the duration of the dry period compared to normal precipitation levels. This atmospheric phenomenon is region-specific, as it depends entirely on rainfall deviations from the long-term historical average, serving as the primary precursor to agricultural and hydrological droughts.

22. (D) Shifting from cereals to short-duration pulses or oilseeds
When the monsoon is severely delayed until late August, long-duration cereals cannot complete their life cycle before soil moisture depletes. Under these circumstances, contingent crop planning requires shifting to short-duration pulses, oilseeds, or fodder crops. These alternative crops mature rapidly and require significantly less water to produce sustainable yields.

23. (B) Thinning of crop stands
During prolonged mid-season dry spells, available soil water is insufficient to support the initial plant population. Removing selected plants through thinning reduces the total leaf area index and canopy transpiration. This practice conserves limited soil moisture for the remaining plants, helping them survive the drought period and produce viable yields.

24. (C) Phenyl mercuric acetate (PMA)
Phenyl mercuric acetate acts as a stomata-closing anti-transpirant by biochemically inducing the partial closure of guard cells. This physiological response increases stomatal resistance to water vapor diffusion, thereby reducing transpiration rates. It must be applied in low concentrations to minimize negative effects on carbon dioxide assimilation and plant photosynthesis.

25. (C) I and IV
Tillage only temporarily decreases soil bulk density; over time, the soil compacts and density increases. Additionally, sandy soils actually possess lower total porosity compared to clay soils, despite having larger individual pores. Because statements one and four are factually incorrect, they represent the correct choices regarding soil physical properties.

26. (A) Evapotranspiration
Evapotranspiration combines physical evaporation from soil and vegetative surfaces with biological transpiration from plants. This joint process serves as the primary mechanism returning water to the atmosphere, accounting for the vast majority of water transfer in terrestrial ecosystems and playing a central role in driving the global hydrological cycle.

27. (B) Osmotic potential
Saline soils contain high concentrations of dissolved soluble salts in the soil solution. This increases the solute concentration, which significantly lowers the osmotic potential of the soil water. As a result, the total soil water potential decreases, making it extremely difficult for plant roots to extract water against this gradient.

28. (B) Permanent Wilting Point
The permanent wilting point represents the soil moisture content at which plants can no longer extract water fast enough to meet transpirational demands. At this point, typically occurring at a matric potential of negative one and a half megapascals, leaves wilt irreversibly, representing the lower boundary of available water.

29. (A) Transpiration rate exceeding the rate of water absorption
Midday wilt occurs when atmospheric evaporative demand is extremely high, causing transpiration rates to exceed the rate of water absorption by roots. Even if soil moisture is adequate, physical resistance within the plant vascular system limits water transport velocity, leading to a temporary loss of turgor pressure in leaves.

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30. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Coniferous forests exhibit higher interception losses than broad-leaved forests during light rain. This is because their dense, needle-like canopy structure provides a much larger cumulative surface area for water storage. Additionally, their high aerodynamic roughness enhances evaporation rates, making the reason a scientifically accurate explanation of the observed assertion.

31. (D) Basic infiltration rate
As water enters a dry soil profile, the infiltration rate declines exponentially due to the gradual

reduction of the matric suction gradient. Eventually, the rate stabilizes and reaches a nearly constant minimum value known as the basic infiltration rate, which is primarily governed by the saturated hydraulic conductivity of the soil.

32. (C) Presence of a dense subsoil hardpan or argillic clay
A dense subsoil hardpan or compacted argillic clay layer exhibits extremely low saturated hydraulic conductivity. This restricting layer physically impedes the downward percolation of water through the soil profile. Consequently, the overlying soil horizons quickly become saturated, causing infiltration to drop and triggering rapid generation of surface runoff.

33. (B) Farmyard manure
Farmyard manure serves as an excellent source of organic matter that stimulates microbial activity in the soil. During decomposition, soil microbes produce polysaccharides and mucilages that bind individual particles into stable aggregates. This structural improvement increases macroporosity and water-holding capacity, significantly enhancing the overall soil infiltration rate.

34. (D) Runoff coefficient
In the Rational formula for estimating peak runoff, the coefficient represents the dimensionless runoff coefficient. This value reflects the fraction of total rainfall that converts into surface runoff, accounting for catchment characteristics such as land slope, vegetation cover, soil permeability, and antecedent soil moisture conditions during a storm.

35. (A) P-2, Q-1, R-4, S-3
Runoff mechanisms vary by hydrologic conditions. Hortonian flow occurs when rainfall intensity exceeds infiltration capacity. Saturation overland flow happens when the water table rises to the surface. Subsurface flow represents lateral water movement in the vadose zone, while return flow occurs when groundwater exfiltrates back to the surface.

36. (B) Lag time
Lag time is a key hydrograph parameter that describes the delay in catchment response to rainfall. It is defined as the time interval between the centroid of effective rainfall and the peak of direct runoff. This index reflects the combined effects of watershed shape, channel length, and slope.

37. (A) Splash erosion
Splash erosion is the initial stage of the water erosion process. It is caused by the kinetic energy of falling raindrops impacting bare soil surfaces. This impact breaks down soil aggregates, detaches individual soil particles, and launches them into the air, while also sealing soil pores to reduce infiltration.

38. (D) K factor
The soil erodibility factor, designated as the K factor, represents the inherent susceptibility of a soil to detachment and transport by water. It is determined by soil physical properties such as texture, organic matter content, structure, and permeability, reflecting how easily a specific soil type erodes under standard conditions.

39. (B) By absorbing kinetic energy of rain and reducing runoff speed
Organic mulches provide a protective physical barrier over the bare soil surface. This layer absorbs the kinetic energy of falling raindrops, preventing soil detachment and surface sealing. Furthermore, the physical obstruction of the mulch slows down overland flow, increasing infiltration opportunities and conserving valuable soil moisture.

40. (B) II, III, and IV
Contour bunding is suited for low rainfall areas, not high rainfall areas where water drainage is needed. Mechanical measures are also typically more expensive than biological ones. Since statements two, three, and four accurately describe bench terracing, graded bunding, and trenching, they represent the correct set of statements.

41. (D) Alley cropping
Alley cropping is an agroforestry system where food crops are grown in the alleys formed between hedges of fast-growing leguminous shrubs or trees. These hedges are regularly pruned, and the prunings are applied as mulch. This layout controls erosion, improves soil organic matter, and enhances in-situ moisture retention on sloping lands.

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ANSWERS

1. (B) Soil texture
Soil texture determines the relative proportion of sand, silt, and clay particles in a soil profile. This particle size distribution directly influences the pore size distribution, specifically the ratio of large non-capillary macropores to small capillary micropores. Consequently, it establishes the fundamental physical foundation that governs soil moisture retention capacity.

2. (D) $P = Q + E + \Delta S$
The catchment water balance equation is based on the principle of conservation of mass. Within any specified hydrological unit, the total incoming precipitation must equal the sum of all outgoing water losses and the change in storage. These losses primarily include surface runoff and evapotranspiration, while storage represents changes in soil moisture and groundwater.

3. (A) Gravitational potential
Under fully saturated soil conditions, all pore spaces are completely filled with water, which eliminates matric suction forces. Consequently, the movement of water through the soil profile is primarily driven by the hydraulic gradient created by gravity and hydrostatic pressure, making gravitational potential the dominant force governing downward percolation and saturated flow.

4. (C) -0.01 to -0.033 MPa
Field capacity represents the amount of water remaining in the soil after free drainage by gravity has ceased. In medium-textured soils, this stable moisture state is reached at a matric potential range of negative one-hundredth to negative thirty-three thousandths of a megapascal, representing the upper limit of plant-available water.

5. (A) Transpiration-induced tension gradient
The continuous ascent of water through the xylem is explained by the cohesion-tension theory. Evaporation of water from leaf mesophyll cells creates a strong negative pressure or tension. This pull is transmitted downward through a continuous water column to the roots, utilizing the cohesive and adhesive properties of water molecules to drive transport.

6. (D) Depression storage
Depression storage represents the volume of water temporarily retained in small puddles, land depressions, and micro-relief features on the soil surface. This water is prevented from forming immediate surface runoff and either gradually infiltrates into the soil profile or evaporates directly back into the atmosphere after the precipitation event ends.

7. (B) To prevent lateral water flow from the inner ring
In a double-ring infiltrometer test, water is maintained in both rings simultaneously. The outer ring acts as a buffer zone that saturates the surrounding soil. This configuration forces the water from the inner ring to flow strictly in a vertical downward direction, preventing lateral spreading and ensuring accurate measurement of vertical infiltration.

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8. (C) It decreases infiltration rate by reducing water opportunity time on soil
A steeper topographic slope increases the gravitational force acting parallel to the ground surface. This accelerates the velocity of overland flow, allowing less time for water to remain in contact with the soil. Consequently, the opportunity time for infiltration is significantly reduced, leading to lower cumulative infiltration and increased surface runoff.

9. (D) Gypsum
Sodic soils exhibit high exchangeable sodium percentages, which cause soil clay particles to disperse and clog pore spaces. Gypsum provides soluble calcium ions that displace sodium ions from the exchange complex. This chemical exchange promotes soil flocculation and structural stability, which significantly enhances water infiltration and structural permeability.

10. (D) (A) is false but (R) is true.
The Soil Conservation Service Curve Number method assigns lower curve numbers to soils with high infiltration capacities because they

52. (C) Change in soil moisture and groundwater storage
In the catchment water balance equation, the term represents the change in total water storage within the hydrological unit over time. This parameter integrates changes in soil moisture content across the root zone, water stored in surface depressions, and fluctuations in the underlying groundwater table.

53. (A) Gravitational potential
When studying water movement through horizontal soil columns under unsaturated conditions, the elevation of the soil remains constant. Consequently, there is no vertical gravitational gradient driving water flow. The movement is instead entirely dominated by matric suction gradients, allowing researchers to safely neglect gravitational potential during analysis.

54. (D) Field Capacity and Permanent Wilting Point
Available water capacity represents the volume of water that plants can easily extract from the soil. It is calculated as the difference between field capacity, which is the upper limit of useful water storage, and the permanent wilting point, which marks the lower limit beyond which plants cannot absorb water.

55. (B) P-3, Q-1, R-4, S-2
Soil water potential components depend on distinct physical factors. Matric potential is driven by capillary and adsorptive forces. Osmotic potential is determined by solute concentration in the soil water. Gravitational potential relates directly to elevation, while pressure potential is governed by submergence depth in saturated conditions.

56. (C) Root cortex to xylem
Under well-watered conditions, liquid water moves relatively easily through the soil and xylem vessels. However, moving water across the living cells of the root cortex to the xylem involves crossing highly selective membranes, including the endodermis with its Casparian strip. This biological barrier presents the highest resistance to liquid flow.

57. (D) Stemflow
Stemflow is the portion of precipitation that is intercepted by the plant canopy and subsequently channeled down the branches and main stem or trunk. This process concentrates water delivery directly to the soil surrounding the base of the plant, enhancing localized soil moisture and root water availability.

58. (A) Matric suction gradient
When water is first applied to a dry soil, the initial infiltration phase is dominated by a very high matric suction gradient. The dry soil particles exert strong capillary and adsorptive forces that rapidly pull water into the dry pores, far exceeding the influence of gravitational forces at this stage.

59. (B) Steep land slope
A steep land slope increases the downslope component of gravity, accelerating the velocity of overland water flow. This rapid movement quickly drains water away from the area, reducing the opportunity time for water to pond and infiltrate. Consequently, it decreases total infiltration and increases the volume of runoff.

60. (B) I and III
Adding organic matter enhances soil aggregation and increases infiltration. Similarly, synthetic soil conditioners like polyacrylamide stabilize structure and maintain high infiltrability. However, tillage only temporarily increases macroporosity, as soil compacts over time. Since statements one and three are correct, they represent the correct combination of soil amendments.

61. (A) Completely impermeable surface like urban concrete
In the Soil Conservation Service Curve Number method, the curve number ranges from zero to one hundred. A value of one hundred represents a completely impermeable surface, such as urban concrete or asphalt. Under this condition, the soil has zero infiltration capacity, meaning all rainfall is converted directly into surface runoff.

62. (A) Phi-index
The phi-index is a simple infiltration index used in hydrology. It represents a constant rate of infiltration throughout a storm. Any rainfall intensity exceeding this index value is converted into direct runoff, while rainfall below this rate is assumed to infiltrate completely into the soil profile.

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42. (A) To prevent seepage of water through the earthen embankment
Earthen embankments are susceptible to piping and structural failure due to water seepage. A core wall, constructed of highly impermeable material like clay or concrete, is built within the center of the dam. This barrier cuts off lateral seepage paths, ensuring structural stability and preventing water loss from the reservoir.

43. (B) Applying cetyl alcohol over the water surface
In arid regions, evaporation from open water surfaces represents a major loss of harvested water. Applying monomolecular chemical films, such as cetyl alcohol, creates an extremely thin, non-toxic barrier on the water surface. This film physically restricts water molecules from escaping into the air, significantly reducing evaporation rates.

44. (C) Area between 10,000 and 50,000 hectares
According to the standard watershed hierarchy used in India, a sub-watershed is a medium-sized hydrological unit. It covers an area ranging from ten thousand to fifty thousand hectares. Delineation at this scale is useful for regional planning, monitoring drainage networks, and implementing large-scale soil and water conservation projects.

45. (C) Mini-watershed → Micro-watershed → Sub-watershed
Delineation of watersheds follows a strict size hierarchy. In this classification system, a mini-watershed represents the smallest unit, followed by a micro-watershed, which ranges from five hundred to one thousand hectares. The sub-watershed represents a much larger scale, making this sequence correct from smallest to largest geographical area.

46. (C) To systematically observe and discuss ecological and farming conditions with locals
A transect walk is a participatory rural appraisal tool that involves walking a cross-section of the watershed with local community members. This exercise facilitates direct observation of land-use patterns, soil types, and conservation issues, while prompting discussions with farmers to integrate indigenous knowledge into the watershed planning process.

47. (D) Agricultural drought
A prolonged meteorological drought reduces rainfall, which quickly depletes soil moisture reserves. When soil moisture becomes insufficient to support normal crop growth and development, it leads directly to agricultural drought. This stage is characterized by crop water stress, wilting, and potential crop failure before hydrological reserves are fully depleted.

48. (C) Harvesting the crop for fodder if grain setting fails
Early withdrawal of the monsoon causes severe moisture stress during reproductive growth, often leading to complete grain failure. Under such contingent conditions, farmers are advised to harvest the standing crop immediately for use as green or dry livestock fodder, preserving some economic value and preventing total crop investment loss.

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49. (B) Soil mulch creation via shallow inter-cultivation
Shallow inter-cultivation breaks the continuity of capillary pores in the upper soil layer, creating a loose soil mulch. This physical disruption reduces the upward movement of water from deeper zones, minimizing evaporation losses. This practice conserves soil moisture for crop roots during mid-season dry spells without altering plant population.

50. (C) (A) is true but (R) is false.
Film-forming anti-transpirants like hexadecanol coat leaves with a physical barrier to block water vapor escape. However, this thin layer also impedes the diffusion of carbon dioxide into the leaf interior. Consequently, it inevitably reduces the rate of photosynthesis, making the assertion true but the accompanying reasoning scientifically incorrect.

51. (A) Crumb
A crumb soil structure consists of porous, spherical aggregates that are loosely arranged. This structural type features a high proportion of both macropores and micropores, resulting in the highest total porosity and water retention capacity at saturation. This physical configuration provides optimal conditions for plant root development and aeration.

74. (A) Removal of lower mature leaves via leaf stripping
Leaf stripping is a mechanical mid-season correction practice used during dry spells. Removing the older, lower leaves, which contribute less to photosynthesis but still transpire water, reduces the total plant canopy area. This decreases overall transpiration losses, helping the crop conserve limited soil moisture and survive prolonged drought periods.

75. (B) P-3, Q-1, R-4, S-2
Anti-transpirants are classified by their mode of action. Kaolin acts as a reflectant by coating leaves to reflect sunlight. Phenyl mercuric acetate induces stomatal closure. Mobileaf is a film-forming chemical that creates a physical barrier, while Cycocel acts as a growth retardant to reduce vegetative growth.

76. (B) Bulk density
Soil bulk density is defined as the dry mass of soil divided by its total volume, which includes both the solid particles and the pore spaces. This physical property is highly sensitive to soil compaction and organic matter content, serving as a key indicator of soil structural quality and aeration.

77. (A) +100 mm
According to the catchment water balance equation, precipitation equals the sum of runoff, evapotranspiration, and change in storage. Substituting the given values, eight hundred millimeters equals seven hundred millimeters of losses plus the change in storage. Solving this relationship yields a positive storage increase of exactly one hundred millimeters.

78. (C) The reduction in energy due to capillary and adsorptive forces of solids
Matric potential is a negative component of soil water potential that occurs under unsaturated conditions. It represents the reduction in water energy caused by adhesive forces between water molecules and soil solid surfaces, along with cohesive forces within capillary pores. This potential governs water retention and movement in unsaturated soils.

79. (D) Strong adhesion to soil particles as hygroscopic water
At the permanent wilting point, most available soil water has been depleted. The remaining moisture is held very tightly within the narrowest pores and as a thin film directly on the surfaces of soil particles. This water is retained primarily by strong adhesive forces, making it unavailable to plants.

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80. (A) I, III, and IV
Water movement through the continuum is a passive process driven by water potential gradients from high to low. Atmospheric water potential is much lower than soil potential, creating a driving force via vapor pressure deficits. Xylem vessels provide low resistance, while stomatal closure increases resistance, making statements one, three, and four correct.

81. (B) Canopy interception loss
Canopy interception loss refers to the portion of rainfall that lands on leaves, branches, and stems but evaporates directly back into the atmosphere without ever reaching the ground. This process represents a direct hydrologic loss to the catchment, reducing the net amount of water available for infiltration and runoff.

82. (D) Horton's Equation
Horton's equation is a widely used empirical model that describes the exponential decay of infiltration rate over time during a rain event. It assumes that infiltration starts at a high initial rate and decreases exponentially to a constant basic rate as the soil profile becomes increasingly saturated with water.

83. (A) Rapid decrease in infiltration rate due to pore sealing
Swelling clays like smectite expand significantly upon wetting as water molecules enter the clay lattice layers. This expansion causes individual clay aggregates to swell and disperse, physically sealing the soil macropores. Consequently, this process leads to a rapid and drastic reduction in the infiltration rate of the soil.

84. (C) Tied ridging
Tied ridging is an in-situ moisture conservation practice that involves creating parallel ridges across the field slope and tying them together with small cross-dams at regular intervals. This grid-like pattern creates small basin-like depressions that retain surface runoff, giving water more opportunity time to infiltrate into the soil profile.

85. (B) II → III → I → IV
Runoff generation during a storm follows a logical progression. First, rainfall begins. As rain continues, the rainfall intensity eventually exceeds the soil's infiltration capacity. The excess water then fills small surface depression storage areas. Once this depression storage is completely filled, active surface runoff commences across the land.

86. (D) Base time
The base time of a hydrograph represents the total duration of direct runoff resulting from a storm event. It measures the time span from the initial rise of the hydrograph limb to the point where direct runoff ceases on the recession limb, excluding any baseflow contribution from the catchment.

87. (B) Transportation of detached soil particles
In the water erosion process, raindrop impact is primarily responsible for detaching soil particles from the soil matrix. Once these particles are detached, overland flow or surface runoff acts as the primary transport agent, carrying the suspended sediment downslope until the flow velocity decreases and deposition occurs.

88. (C) LS factor
The LS factor in the soil loss equation combines the effects of slope length and slope steepness. It compares soil loss from a specific field site to a standard unit plot, reflecting how topographic characteristics accelerate runoff velocity and volume, thereby increasing the overall vulnerability of the land to water erosion.

89. (D) Conservation tillage and stubble mulching
Conservation tillage and stubble mulching involve leaving crop residues from the previous harvest on the soil surface rather than plowing them under. This protective residue layer absorbs the physical impact of raindrops, prevents surface crusting, slows down overland flow, and significantly enhances soil water retention and organic matter content.

90. (D) (A) is false but (R) is true.
Contour bunds are not recommended for clayey black cotton soils in high rainfall regions because these soils swell, have poor drainage, and can cause waterlogging or structural failure of the bunds. However, the reason is correct because these soils do require drainage. Thus, the assertion is false, but the reason is true.

91. (B) To reduce shading on the intercropped food plants
In alley cropping systems, fast-growing trees or shrubs form dense hedges. Regularly pruning these hedgerows is essential to manage canopy size and prevent excessive shading of the food crops growing in the adjacent alleys. The cut foliage is also used as a green mulch to conserve soil moisture.

92. (B) Percolation tank
A percolation tank is an artificial recharge structure constructed across natural drainage lines. It is designed to impound surface runoff during rainy periods and hold it long enough to facilitate downward seepage into the soil. This process directly recharges the underlying unconfined aquifers, raising local water table levels.

93. (A) Crown Root Initiation (CRI))
Crown root initiation, occurring around twenty-one days after sowing, is the most critical growth stage for water in wheat crops. Moisture stress during this period severely restricts root development and tiller formation, leading to drastic yield reductions. Applying life-saving irrigation at this stage maximizes water productivity and crop yield.

94. (C) Topographic ridgelines defining drainage divides
Delineating a watershed is based purely on physical geomorphology rather than administrative boundaries. The watershed boundary is defined by topographic ridgelines, also known as drainage divides. Rainfall falling on one side of this divide drains into the designated watershed, while water on the other side flows into an adjacent basin.

95. (D) P-2, Q-4, R-1, S-3
Watershed components are defined by specific spatial and hydrologic properties. The catchment is the total area draining into a common point, while the drainage divide is the ridge separating watersheds. The outlet is the lowest exit point, and the time of concentration is the travel time from the most remote point.

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96. (C) Time line and historical transect maps
The timeline and historical transect maps are participatory rural appraisal tools used to document long-term changes within a community. By collaborating with elderly villagers, researchers can map historical shifts in land use, forest cover, water resource availability, and village infrastructure, providing valuable context for planning sustainable watershed interventions.

97. (B) Depletion of surface water and groundwater reservoirs
Hydrological drought is characterized by a significant reduction in water supplies across the region. This stage of drought is identified by depleted water levels in streams, rivers, lakes, and reservoirs, along with a noticeable decline in groundwater tables, occurring long after a meteorological drought has originally set in.

98. (D) Built-in flexibility and readiness for alternate crops
Contingent crop planning is designed to cope with unpredictable weather aberrations such as delayed monsoons or dry spells. Its fundamental strength lies in its built-in operational flexibility and prepared packages of practices. This readiness allows farmers to quickly switch to alternate, short-duration crop options and minimize agricultural economic risks.

99. (A) Thinning every third row to lower plant population density
When a severe dry spell occurs forty days after sowing, the soil moisture cannot support the initial plant population. Removing every third row reduces the total crop leaf area and transpirational demand. This mechanical thinning conserves limited soil water, allowing the remaining plants to survive and complete their life cycle.

100. (B) I and II
Cycocel acts as a growth retardant that reduces shoot growth and increases root depth, helping plants avoid drought. Kaolin is a safe, reflectant material that lowers leaf temperature and transpiration. However, phenyl mercuric acetate is toxic and not safe for food crops. Thus, statements one and two are correct.

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101. (A) Porosity
Porosity represents the volume of all pore spaces or voids divided by the total volume of the soil mass. This physical property determines the soil's capacity to hold water and air, and is directly influenced by soil texture, structure, compaction, and organic matter content in the soil profile.

102. (D) Geothermal heat flux
The catchment water balance equation accounts for water mass movement. It includes incoming precipitation, outgoing evapotranspiration, streamflow runoff, and changes in soil and groundwater storage. Geothermal heat flux represents a deep underground energy transfer that has no direct, measurable impact on the water balance of a catchment system.

103. (B) Matric potential
In saturated soils, all pore spaces are completely filled with water, meaning there are no active capillary or adsorptive forces acting on unsaturated water films. Because matric suction only exists when air-water interfaces are present in soil pores, the matric potential component is strictly zero under fully saturated conditions.

104. (C) Silt loam
Available water capacity is determined by the difference between field capacity and permanent wilting point. Silt loam soils have a balanced combination of macropores and micropores. This texture retains more available water than sandy soils, which drain too quickly, and clay soils, which hold water too tightly for plants.

105. (B) II only
Water movement through plants is a passive process driven by transpiration, regulated by stomata, and occasionally interrupted by cavitation. Resistance to water flow is highest in the leaf-to-atmosphere boundary layer and the root membranes, not the hollow xylem vessels. Because only statement two is incorrect, it represents the correct answer.

106. (A) Infiltration and evaporation
Depression storage represents water retained in small surface hollows, puddles, and micro-relief depressions during precipitation. Once rainfall commences, these depressions fill rapidly. This trapped water is simultaneously and immediately lost through two pathways: downward entry into

surface area of the soil matrix, which directly enhances the soil's water retention capacity.

185. (D) I in mm/hr, A in hectares
The Rational Method is a widely used empirical formula for estimating peak runoff discharge. In the standard metric form of the equation, the rainfall intensity must be expressed in millimeters per hour, and the catchment drainage area must be specified in hectares. Applying these specific units in the equation directly yields the peak discharge in cubic meters per second.

186. (A) Subsurface return flow and baseflow
The recession limb of a stream hydrograph represents the withdrawal of water from storage after rainfall has ceased. The discharge does not drop to zero immediately because water continues to drain from the catchment. This slow tailing off is sustained by the gradual release of subsurface return flow and steady baseflow from shallow groundwater storage.

187. (B) Terminal velocity and mass of raindrops
Soil detachment is the initial phase of water erosion where soil aggregates are broken apart into individual particles. The capacity of rainfall to cause this detachment is determined by its kinetic energy. This energy is a function of the falling raindrops' terminal velocity and total mass, which dictate the physical impact force applied to the soil.

188. (B) Continuous bare fallow with up-and-down slope tillage
In the Universal Soil Loss Equation, the cover management factor, or C factor, compares soil loss from a specific cropping system to a reference condition. A C value of one point zero represents the worst-case erosion scenario. This corresponds to continuous bare fallow land that is tilled up and down the slope, offering no protection against erosion.

189. (A) Decreasing surface runoff and evaporation
Applying mulch to the soil surface significantly alters the localized water balance. The mulch layer acts as a physical barrier that intercepts raindrop impact, preventing surface sealing and thereby maintaining high infiltration rates. Furthermore, it insulates the soil surface from solar radiation, which drastically reduces evaporation losses and minimizes runoff generation during rainstorms.

190. (A) Both A and R are true and R is the correct explanation of A.
Contour trenching is a highly effective conservation measure for afforestation on steep, degraded slopes. By excavating trenches across the slope along constant elevation lines, the continuous slope length is physically broken. This configuration intercepts surface runoff, slows its velocity, and forces it to infiltrate, providing localized soil moisture that supports the survival of young tree seedlings.

191. (D) Safely conduct excess runoff away without causing gully erosion
Grassed waterways are wide, shallow channels established with dense, sod-forming vegetation. In watershed management, they are designed to receive concentrated surface runoff from outlet channels or terraces. The dense grass lining stabilizes the channel bed, protecting it from high shear stress. This allows the waterway to safely conduct excess runoff downslope without triggering gully erosion.

192. (C) Swelling clays naturally seal the pond bottom to minimize seepage
Vertisols are characterized by a very high content of swelling clay minerals, primarily montmorillonite. When these soils are wetted, the clay particles expand significantly, closing up cracks and pore spaces. In farm ponds, this swelling behavior naturally seals the pond bottom and sides, creating a highly impermeable barrier that minimizes seepage losses without requiring synthetic liners.

193. (B) High evaporation and seepage losses limiting storage duration
In arid regions, harvested rainwater is crucial for supplemental irrigation, but storing it is highly challenging. High atmospheric temperatures and low relative humidity trigger rapid evaporation, while porous soils lead to high seepage rates. These factors limit the duration of storage, acting as the primary constraint to utilizing harvested water effectively during critical crop growth stages.

194. (D) Horton-Strahler system
The Horton-Strahler stream ordering system is a standard method used to describe the branching hierarchy of a river basin. Under this system, headwater streams are designated as first-order. When two streams of order 'n' join, they form

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along contours. As overland runoff flows downslope, it encounters this physical barrier. The dense stems and root systems drastically reduce the velocity of the runoff water. This slow movement facilitates sediment deposition behind the barrier while promoting greater localized water infiltration.

117. (A) A half-moon earthen bund to capture runoff around trees
A semi-circular bund is a localized rainwater harvesting structure shaped like a half-moon. Constructed with earth, these low-height bunds are aligned facing upslope to intercept and collect overland runoff. They are specifically designed to concentrate moisture around individual tree basins or newly planted seedlings in arid and semi-arid rangelands, supporting establishment.

118. (D) Drip irrigation
Harvested rainwater is a highly precious and limited resource in dryland regions. To optimize its utilization, a highly localized and precise delivery system is required. Drip irrigation applies water directly to the plant root zone at low discharge rates, minimizing losses from evaporation and deep percolation, thereby achieving the highest water use efficiency for supplemental irrigation.

119. (B) Socio-ecological system
While a watershed is geographically defined by topographical boundaries, integrated watershed management must address the interactions between humans, agriculture, and natural resources. It is therefore conceptualized as a socio-ecological system. This holistic approach integrates biophysical resource conservation with the livelihood security, economic development, and social needs of the communities residing within the boundary.

120. (A) I, II, and IV
Participatory Rural Appraisal involves various visual and interactive tools designed to facilitate community planning. Visual tools like social mapping help identify households and structures, allowing illiterate members to participate easily. Matrix scoring enables the community to prioritize local problems. It values local indigenous knowledge and produces flexible, dynamic development plans rather than rigid master plans.

121. (D) Soil moisture availability during critical crop growth
An agricultural drought is characterized by a severe soil moisture deficit that occurs during critical stages of crop growth. Unlike meteorological or hydrological droughts, which focus on total rainfall or water reserves, an agricultural drought directly impacts plant health because the soil moisture within the root zone falls below the crop's minimum transpiration and metabolic demands.

122. (A) Pearl millet or short-duration mungbean
When the monsoon is severely delayed beyond mid-August in central India, standard long-duration crops like cotton or pigeonpea cannot complete their lifecycle. Under contingent planning, farmers are advised to sow highly drought-resilient, short-duration crops. Pearl millet or short-duration mungbean are optimal choices as they mature quickly and utilize the limited remaining soil moisture profile.

123. (B) Removing weed competition for limited soil moisture
Weeds are highly competitive plants that rapidly transpire significant quantities of water from the soil. During a mid-season dry spell, available soil moisture is highly restricted. Implementing timely weed management practices eliminates these unwanted plants. This directly conserves the scarce water resources, reserving them exclusively for the main crop to sustain growth and prevent wilting.

124. (B) Lowering cellular osmotic potential to maintain turgor
Under moisture stress, plants accumulate compatible solutes such as proline and glycine betaine within their cells. This physiological accumulation acts to lower the cellular osmotic potential relative to the drying soil. By creating this favorable gradient, water is drawn into the cells, enabling the plant to maintain turgor pressure, stomatal conductance, and metabolic activities during drought.

125. (A) I → II → III
Water retention capacity is fundamentally dictated by the total specific surface area of soil particles. Coarse sand particles have the smallest surface area per unit mass, resulting in extremely low water retention. Silt particles possess intermediate surface area and retention.

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with dense, close-growing legumes that protect the soil.

165. (A) Topsoil depth sufficient to prevent bedrock exposure
Bench terracing involves converting steep slopes into a series of flat platforms to prevent erosion. Constructing these terraces requires deep soil cutting and filling operations. Consequently, the primary constraint is the depth of the topsoil. There must be sufficient soil depth to ensure that bedrock is not exposed during excavation, which would ruin agricultural productivity.

166. (D) Along the contour lines
In agroforestry systems established on sloping lands, the spatial arrangement of trees is critical for soil conservation. Tree rows must be aligned strictly along the contour lines of the slope. This configuration acts as a physical barrier that slows downslope runoff, traps moving sediment, and enhances localized water infiltration, thereby preventing sheet and rill erosion.

167. (B) Tanka
A tanka is a traditional rainwater harvesting structure native to the arid regions of Rajasthan. It consists of a circular, plaster-lined underground storage tank covered with a lid. Rainwater is collected from a prepared circular catchment area surrounding the tank. This design prevents evaporation and contamination, securing drinking water throughout the dry season.

168. (C) Flower and pod drop
The reproductive stage of pulse crops is highly sensitive to moisture stress. A severe soil water deficit during this phase triggers abscission, leading to extensive flower and pod drop, which drastically reduces crop yields. Providing a single supplemental irrigation using harvested rainwater during this critical period maintains plant turgor and successfully prevents this crop damage.

169. (D) The Micro-watershed
The Integrated Watershed Management Programme in India utilizes a hierarchical approach for planning and execution. The primary, lowest functional unit of implementation is the micro-watershed, which typically covers an area of five hundred to one thousand hectares. This size allows for detailed biophysical planning and active participation of local communities in executing interventions.

170. (A) Both A and R are true and R is the correct explanation of A.
Participatory Rural Appraisal emphasizes the inclusion of all community segments, especially women and marginalized groups. These groups often have distinct dependencies on common pool resources such as water and fodder. Actively involving them in planning ensures that watershed development interventions address diverse livelihood security needs, facilitating equitable resource distribution and long-term sustainability of the project.

171. (B) 20%
The Indian Meteorological Department has established specific criteria for declaring a country-wide drought year. A drought year is officially declared when the total seasonal monsoon rainfall deficiency for the country exceeds ten percent, and the total area affected by moderate to severe drought conditions simultaneously exceeds twenty percent of the nation's total geographical area.

172. (B) Application of organic mulch crop residues
During a prolonged dry spell, substantial soil water is lost via evaporation from the bare soil surface. Applying organic mulch, such as crop residues or straw, forms a physical barrier over the soil. This barrier insulates the soil, lowering surface temperature, and physically restricts vapor transport to the atmosphere, thereby conserving valuable profile moisture.

173. (A) To break capillary continuity and reduce evaporation
Dust mulching is a dryland moisture conservation practice achieved by shallow hoeing. This tillage operation breaks the soil crust and pulverizes the topsoil into a fine, loose layer of dry soil. This loose dust layer breaks the continuity of capillary pores rising from the deeper soil layers, thereby reducing the upward movement and subsequent evaporation of water.

174. (C) Form a monomolecular film on water to retard evaporation
Hexadecanol, also known as cetyl alcohol, is a long-chain fatty alcohol used for chemical water conservation. When applied to the surface of open water reservoirs, it spontaneously spreads

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The rainfall erosivity factor uses energy and intensity units. The soil erodibility factor represents soil loss per unit of erosivity. The topographic factor represents length and steepness as a dimensionless ratio. The cover management factor is also a dimensionless ratio relative to clean-tilled fallow.

136. (C) The soil profile becomes completely saturated from below upward
Saturation excess runoff, or the Hewlett mechanism, occurs primarily in humid regions with shallow water tables or restrictive soil layers. As rainfall continues, the water table rises, completely saturating the soil profile from the bottom upward to the surface. Once fully saturated, the soil cannot absorb any more water, and all subsequent rainfall becomes surface runoff.

137. (D) Sheet erosion
Sheet erosion is the uniform, gradual removal of a very thin layer of topsoil across a large area. Because it occurs evenly without carving deep channels, it is virtually imperceptible to farmers. It remains unnoticed until a severe decline in crop yields and soil fertility reveals that the nutrient-rich topsoil layer has been lost over time.

138. (A) Broad Bed and Furrow (BBF)
The Broad Bed and Furrow system is an in-situ moisture conservation practice that modifies soil micro-topography. It consists of wide, slightly raised beds separated by parallel furrows. This layout allows excess runoff to collect and slow down in the furrows, promoting infiltration into the beds. It prevents waterlogging while conserving moisture for crop growth during dry periods.

139. (B) By creating miniature reservoirs across the slope to impound water
Contour farming involves conducting all agricultural operations, such as plowing, planting, and cultivating, across the slope along constant elevation lines. This orientation creates countless miniature ridges and furrows that act as small barriers. These barriers intercept downslope overland flow, impounding water in small reservoirs. This increases detention time, promotes infiltration, and significantly reduces soil erosion.

140. (A) Both A and R are true and R is the correct explanation of A.
In areas with high rainfall and heavy clay soils, like vertisols, waterlogging is a major risk because low infiltrability causes water to pond on the surface. Under these conditions, graded bunds are preferred over contour bunds. Graded bunds incorporate a slight longitudinal slope, allowing them to safely carry away and dispose of excess runoff, preventing crop damage.

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141. (A) Induce deposition of suspended sediment
A vegetative filter strip is a band of dense perennial vegetation planted at the lower margin of a cultivated field. As sediment-laden surface runoff flows through this strip, the dense stems physically obstruct and slow down the water flow. This reduction in velocity dramatically decreases the sediment-carrying capacity of the runoff, inducing rapid deposition of suspended soil particles.

142. (C) Weathered, fractured, or porous strata linked to an aquifer
Percolation tanks are artificial recharge structures designed to impound surface runoff and facilitate its downward movement into groundwater reserves. To function effectively, the underlying geological formations must be highly permeable. Weathered, fractured, or porous strata beneath the tank are highly desirable, as they provide open conduits that directly link the ponded water to the target aquifer.

143. (D) Application of bentonite clay or geomembranes
Seepage loss is a major challenge in farm ponds constructed on coarse, highly porous soils. To prevent water from draining rapidly into the ground, the pond bottom must be sealed. Applying bentonite clay, which swells when wet, or installing synthetic geomembranes creates a highly effective, impermeable physical barrier. This treatment successfully retains harvested rainwater for long-term agricultural use.

144. (B) Second or third order
In hydrological terminology, stream ordering classifies the tributary network of a watershed. A mini-watershed, which typically encompasses an area of five hundred to one thousand hectares, is relatively small. Within such a limited catchment area, the drainage network is simple, and the

Clay particles, having microscopic sizes and highly reactive surfaces, exhibit the highest water retention capacity.

126. (C) Reduced hydraulic conductivity from lower macroporosity
A high soil bulk density indicates significant compaction, which dramatically reduces total pore space, especially the volume of large macropores. Because hydraulic conductivity under saturated conditions depends heavily on the presence of continuous macropores, compacted soils exhibit severely reduced water movement. This leads to slow internal drainage, restricted aeration, and highly impeded vertical percolation.

127. (D) Evapotranspiration
A lysimeter is a specialized hydrological instrument consisting of an isolated block of soil, often vegetated, with mechanisms to monitor water inputs and outputs. By precisely measuring changes in mass along with precipitation and drainage, it allows for the accurate, direct determination of water loss to the atmosphere through the combined processes of evaporation and transpiration.

128. (C) It becomes increasingly negative
At field capacity, soil water is held at relatively low suction, corresponding to a slightly negative potential. As the soil dries towards the permanent wilting point, plants extract the easily available water, leaving only thin films held tightly by matrix forces. Consequently, the soil water potential drops significantly, becoming increasingly negative as suction forces rise.

129. (B) Zero
Matric potential represents the attractive forces between soil solid surfaces and water molecules. In a completely saturated soil, all pore spaces are entirely filled with water, and there are no active capillary menisci or adsorptive suction forces pulling on the water. Therefore, at standard atmospheric pressure, the matric potential of saturated soil is precisely zero.

130. (A) Both A and R are true and R is the correct explanation of A.
Transpiration in the soil-plant-atmosphere continuum is driven by physical thermodynamics. The sub-stomatal cavity of a leaf is nearly saturated, maintaining a high water vapor pressure. The surrounding bulk atmosphere has a much lower vapor pressure. This steep gradient drives water vapor diffusion from the leaf to the atmosphere, confirming that water moves spontaneously down this pressure gradient.

131. (A) Interception loss
When precipitation falls on a vegetated canopy, a significant fraction is caught by leaves, branches, and stems. This retained water is held on the plant surfaces and subsequently evaporates directly back into the atmosphere without ever reaching the forest floor. This specific hydrological loss process is termed interception loss and reduces net rainfall.

132. (C) Saturated hydraulic conductivity
At the onset of rain, dry soil exhibits high infiltration due to strong matric suction. As the wetting front penetrates deeper, the soil becomes saturated, and the matric potential gradient approaches zero. Under these conditions, gravity becomes the sole driving force. Thus, the infiltration rate plateaus and equals the saturated hydraulic conductivity of the soil profile.

133. (A) Freeze-thaw cycles inducing soil aggregation and cracking
During winter, frozen soil water blocks pore spaces, virtually stopping infiltration. When thawing occurs, freeze-thaw cycles physically disrupt the soil matrix, causing aggregate formation, structural splitting, and localized cracking. These physical changes temporarily create preferential flow paths and macro-fissures. Consequently, the apparent infiltration rate increases significantly upon thawing, facilitating rapid surface water drainage.

134. (D) Stabilizing surface soil aggregates against dispersion
When rain or irrigation water strikes bare soil, clay particles disperse and clog surface pores, forming a crust that triggers runoff. The application of polyacrylamide, a water-soluble polymer, stabilizes the soil aggregates at the surface. By binding the particles together, it prevents aggregate dispersion, preserves soil structure, maintains high infiltrability, and successfully minimizes runoff.

135. (A) P-4, Q-3, R-2, S-1
The Universal Soil Loss Equation calculates average annual soil loss using multiple factors.

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Consequently, clay retains a much higher moisture content at this potential compared to coarser soils.

155. (A) P-3, Q-1, R-2, S-4
The soil-plant-atmosphere continuum is governed by physical forces. Cohesion represents the mutual attraction between water molecules themselves, maintaining a continuous column. Adhesion is the attraction between water molecules and hydrophilic xylem cell walls. Transpiration is the evaporative loss of water vapor through stomata. Root pressure is the positive hydrostatic pressure generated active in the xylem.

156. (B) passes through the canopy to the ground
When rainfall occurs over a vegetative canopy, the water is partitioned into several pathways. Throughfall refers to the portion of precipitation that falls directly through gaps in the plant canopy or drips from leaves and branches to reach the ground. Unlike stemflow, which runs down the main stem, throughfall covers a wider soil surface area.

157. (A) Soil sorptivity
Soil sorptivity is a physical parameter that represents the capacity of a dry soil to absorb water through capillary suction forces without the aid of gravity. During the initial minutes of a rainfall event on dry soil, the matric potential gradient is extremely steep. Consequently, sorptivity completely dictates the rapid shape and rate of cumulative infiltration.

158. (C) Mechanically breaking the surface crust via hoeing
A compacted surface crust acts as a physical barrier that dramatically reduces soil infiltrability, causing immediate runoff. To restore water intake rapidly, this hard crust must be physically shattered. Mechanically breaking the surface crust through timely hoeing or shallow inter-cultivation opens up macropores, immediately increasing the rate of water entry into the soil profile.

159. (D) Protecting surface aggregates and enhancing biopores
Zero-tillage practices combined with crop residue retention protect the soil from the direct impact of raindrops, preventing physical crusting and aggregate dispersion. Over time, leaving the soil undisturbed encourages the activity of earthworms and other soil macrofauna. This biological activity creates numerous continuous vertical biopores, which significantly enhances the soil's long-term water infiltration capacity.

160. (B) II and III
Hortonian runoff occurs when rainfall intensity exceeds the soil's infiltration capacity, which is very common in arid regions where bare soils are prone to rapid surface crusting. Dense vegetative cover slows down the movement of overland water, increasing the time of concentration. Runoff does not require the entire soil profile to be saturated first.

161. (B) Discharge rate vs. Time
A hydrograph is a fundamental hydrological graph used to analyze catchment response to rainfall. It plots the streamflow discharge rate, usually measured in cubic meters per second, on the vertical axis against elapsed time on the horizontal axis. This visualization displays peak discharge, recession characteristics, and total runoff volume resulting from a storm.

162. (D) Clogging soil macropores with fine particles to seal the surface
Splash erosion occurs when falling raindrops strike bare soil, shattering aggregates. The impact detaches fine clay and silt particles, suspending them in water. As this water begins to infiltrate, these fine particles are washed into soil macropores. This physically clogs and seals the surface pores, creating a crust that restricts infiltration and accelerates runoff generation.

163. (A) R factor
The Universal Soil Loss Equation estimates annual soil loss using multiple factors. The rainfall erosivity factor, or R factor, is determined solely by the geographic climate, representing the kinetic energy and intensity of local rainstorms. Because human activities cannot alter regional meteorological patterns, the R factor remains completely unaffected by any agricultural management interventions.

164. (C) Sorghum planted in wide, open rows
Erosion-permitting crops are those that are planted in wide, open rows and provide poor early canopy cover, leaving the soil surface exposed to raindrop impact. Sorghum is a classic example of an erosion-permitting crop. To minimize soil loss, it is often grown in a strip-cropping system

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highest stream order expected at the outlet is generally a second or third-order channel.

145. (B) Soil and moisture conservation via vegetative cover
The upper reaches, or ridge area, of a watershed represent the headwaters where runoff begins. Implementing intensive engineering structures here is impractical. Instead, the primary objective is to maximize in-situ soil and moisture conservation. Establishing dense vegetative cover, afforestation, and pasture development in this zone intercepts rainfall, reduces runoff velocity, and prevents downslope sediment transport.

146. (C) 19%
The Indian Meteorological Department classifies droughts based on deviation from normal precipitation. A meteorological drought is declared for a region when the cumulative seasonal monsoon rainfall deficiency exceeds nineteen percent of the long-term average. Deficiencies between twenty-six and fifty percent indicate moderate drought, while deviations exceeding fifty percent are classified as severe.

147. (A) Plow the crop and sow a short-duration catch crop
Under contingent crop planning, if a rainfed crop completely fails early in the season due to a severe dry spell, leaving the field empty is uneconomical. The standard recommended action is to immediately plow under the damaged crop and sow a short-duration catch crop or fodder crop. This strategy utilizes subsequent late rains to secure some economic return.

148. (C) Ratooning
Ratooning is a highly effective mid-season correction practice used during severe moisture stress. If a crop is severely damaged by drought, cutting the vegetative shoots just above ground level halts transpiration loss. When favorable soil moisture conditions return with late rains, the remaining healthy root system rapidly sends up new tillers, allowing the crop to regrow.

149. (A) Saving crops from wilting during transient dry spells
Anti-transpirants are chemical compounds applied to plant foliage to reduce water loss. Because they restrict carbon dioxide intake and can lower photosynthesis, their use is not recommended under normal conditions. However, during critical dry spells in rainfed farming, applying these compounds is a vital emergency measure. They save crops from permanent wilting and sustain survival until rains return.

150. (C) A is true but R is false.
Reflectant anti-transpirants, such as kaolin clay, form a thin white coating on the leaf surface when sprayed. This coating increases leaf albedo, which reflects a significant portion of incoming solar radiation. By reflecting this energy, the leaf temperature is actually lowered, which decreases the vapor pressure deficit and transpirational demand without causing stomatal closure.

151. (B) Platy
Platy soil structure is characterized by flat, thin, horizontal soil aggregates or peds. This structural arrangement is commonly found in compacted subsoils or plow pans. The horizontal orientation of the plates severely limits the continuity of vertical pore spaces. Consequently, it creates a physical barrier that restricts downward root penetration and highly impedes vertical water movement.

152. (C) Evapotranspiration
In a closed catchment system with no deep groundwater leakage, the water balance equation simplifies significantly. Over the long term, all incoming precipitation must balance the outputs. Since water cannot escape through deep underground pathways, the difference between total precipitation and measured surface runoff must equal the volume of water returned to the atmosphere through evapotranspiration.

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153. (D) Saline soils
In saline soils, high concentrations of dissolved salts are present in the soil solution. This high solute concentration significantly lowers the osmotic potential of the soil water, creating a highly negative potential. Consequently, the osmotic force becomes the dominant factor restricting water uptake by plants, forcing crops to exert high suction pressure to absorb moisture.

154. (D) Clay
Permanent wilting point is the soil moisture content at which plants can no longer extract water. Clay soils possess a very high proportion of sub-microscopic micropores and a vast internal surface area. These properties exert extremely strong adsorptive and capillary forces on water.

to form a stable, monomolecular film. This ultra-thin film acts as a physical barrier that retards water evaporation to the atmosphere without restricting essential oxygen and carbon dioxide exchange.

175. (A) P-4, Q-3, R-2, S-1
Soil moisture exists in distinct energy states. Field capacity represents the moisture content after free gravitational drainage ceases. Gravitational water is the excess water that drains freely under the influence of gravity. Capillary water is held in soil micropores and is available to plants. Hygroscopic water is bound tightly to soil particles and is completely unavailable.

176. (C) Soil texture
Soil texture refers to the relative proportions of sand, silt, and clay particles within a soil. Unlike bulk density, total porosity, or soil structure, which can be modified by tillage, soil texture is a permanent physical property. Conventional tillage operations cannot alter the size distribution of the primary mineral particles that make up the soil matrix.

177. (B) 10,000 cubic meters
To calculate the total volume of precipitation, the catchment area must be multiplied by the depth of rainfall. A catchment area of ten hectares equals one hundred thousand square meters. A uniform rainfall depth of one hundred millimeters equals zero point one meters. Multiplying these values yields a total precipitation volume of ten thousand cubic meters.

178. (D) Matric potential is negative (suction), whereas pressure potential is positive (submergence)
In soil physics, matric and pressure potential describe different states of water energy. Matric potential is driven by capillary and adsorptive forces in unsaturated soils, resulting in a negative potential or suction. In contrast, pressure potential is generated by the hydrostatic pressure of water in saturated zones below a water table, representing a positive potential.

179. (B) The upper 50-75%
Total available water capacity is the water held between field capacity and the permanent wilting point. However, as the soil dries, water becomes harder for plants to extract. Readily available water represents the fraction of available water that plants can absorb easily without experiencing moisture stress. This fraction generally constitutes the upper fifty to seventy-five percent.

180. (B) I and II
The soil-plant-atmosphere continuum describes water movement down a energy gradient. Leaf water potential must be lower than root water potential for water to rise. Under severe stress, xylem cavitation occurs, creating air bubbles that disrupt this continuous water column. Soil water potential directly influences the gradient, thereby controlling the overall rate of transpiration.

181. (A) Canopy interception
Canopy interception represents the fraction of precipitation that is captured by leaves and stems and evaporates before reaching the soil. This process is directly controlled by the Leaf Area Index of the forest canopy. A higher index represents a denser leaf area, which provides more surface area to intercept and store falling rain, increasing interception loss.

182. (D) Matric potential
When rainfall first contacts dry soil, the initial rate of infiltration is extremely high. This rapid water movement is driven by a very steep matric potential gradient between the wet soil surface and the highly dry soil below. This capillary suction force initially dominates over gravitational forces, drawing water rapidly into the dry soil matrix.

183. (B) A sandy soil under pasture
The final basic infiltration rate of a soil depends heavily on its texture and surface cover. A sandy soil naturally contains a high proportion of large macropores, which facilitate rapid water movement. Under permanent pasture cover, the soil is protected from compaction and crusting, and root channels enhance macroporosity, yielding the highest basic infiltration rate.

184. (C) Adding highly porous carbon structures to increase total porosity
Biochar is a highly porous, stable carbon material produced through the pyrolysis of organic biomass. When added to degraded soils, it does not increase bulk density or repel water. Instead, its highly porous internal structure significantly increases the total pore volume and specific

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the soil profile via infiltration, and direct vapor loss back to the atmosphere through evaporation, quickly depleting the surface-stored volume.

107. (B) The drop in water level in the inner ring only
A double-ring infiltrometer consists of concentric inner and outer rings inserted into the soil. The outer ring serves as a buffer zone, preventing lateral spreading of water and ensuring strictly vertical downward flow beneath the inner ring. Consequently, the actual infiltration rate is determined exclusively by measuring the drop in water level within the inner ring.

108. (B) It causes infiltration to cease upon complete profile saturation
When a shallow water table is present close to the soil surface, the storage capacity of the soil profile is highly constrained. As water infiltrates, the remaining unsaturated pore space is rapidly filled. Upon reaching complete saturation of the entire soil profile up to the surface, the hydraulic gradient drops, causing infiltration to completely cease.

109. (A) Hoed inter-cultivation
Soil surface crusting significantly reduces infiltrability by sealing macropores. To restore water intake capacity without chemical inputs, physical intervention is necessary. Inter-cultivation using a hand hoe or mechanical weeder physically breaks and pulverizes the hard surface crust. This manual disruption opens up the soil structure, facilitating rapid entry of rainfall and minimizing immediate surface runoff.

110. (D) A is false but R is true.
The Rational formula is highly empirical and strictly designed for small watersheds, typically less than fifty square kilometers, because it assumes uniform rainfall intensity over the entire catchment duration. For very large river basins, rainfall is highly variable in space and time, making this assumption invalid, which renders the model unsuitable for large-scale peak runoff estimation.

111. (D) Rainfall intensity and duration
The rising limb of a stream hydrograph represents the rapid increase in streamflow resulting from surface runoff generation. The rate of this rise is primarily controlled by the intensity and duration of the storm event. High-intensity rainfall swiftly exceeds soil infiltration capacity, generating substantial overland flow that quickly elevates the hydrograph, defining its steep upward trajectory.

112. (C) Micro-channels that can be erased by normal tillage
Rill erosion represents an intermediate stage of water erosion where surface runoff concentrates in numerous, well-defined micro-channels. These small channels are shallow enough to be easily smoothed over and obliterated by normal agricultural tillage operations. Unlike deep gullies, rills do not present a permanent obstacle to the passage of farm machinery across the field.

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113. (B) Contour farming, strip cropping, and terracing
In the Universal Soil Loss Equation, the conservation support practice factor accounts for the ratio of soil loss with a specific practice to that with straight-row farming. This factor directly reflects the erosion-reducing benefits of physical, contour-aligned interventions. These include contour farming, vegetative strip cropping, and constructing terraces, which slow down runoff velocity.

114. (D) By absorbing and breaking the kinetic energy of raindrops
Soil detachment is primarily initiated by the high kinetic energy of falling raindrops striking bare, unprotected soil. A well-established cover crop provides complete physical protection to the soil surface. The dense foliage intercepts the raindrops, absorbing and dissipating their impact energy before they touch the ground, thereby preventing aggregate breakdown, sealing, and subsequent soil particle detachment.

115. (A) Contour bunding → Graded bunding → Bench terracing
Mechanical soil conservation measures are implemented based on field slope gradients. Contour bunding is suited for mild slopes up to six percent in low rainfall areas. Graded bunding is deployed on slopes of two to ten percent in high rainfall zones. Bench terracing is constructed on steep hill slopes ranging from sixteen to thirty-three percent.

116. (C) Reducing overland runoff velocity as a dense physical filter
Vegetative barriers consist of dense, closely spaced perennial grass or shrub strips planted

a downstream channel of order '$n+1$'. This quantitative classification is widely used to analyze catchment geomorphology and drainage.

195. (A) P-2, Q-1, R-3, S-4
Participatory Rural Appraisal utilizes specialized visual and spatial tools to capture community knowledge. A resource map identifies the spatial distribution of key natural resources. A seasonal calendar analyzes annual variations in climate, labor, and cropping patterns. A Venn diagram illustrates institutional relationships, while a transect walk involves direct observation of physical topography and soil variations.

196. (C) Soil moisture is insufficient to meet crop evapotranspiration demand
An agricultural drought represents a specific soil moisture deficit that directly impairs crop performance. It is declared when the available water stored within the crop's root zone is insufficient to meet the plant's potential evapotranspiration demand. This deficit leads to water stress, reduced cell turgor, impaired growth, and eventual crop failure if moisture is not replenished.

197. (A) Castor
Castor is a highly resilient, deep-rooted crop that is widely recommended in dryland contingent planning. Its deep taproot system allows it to extract moisture from deeper soil layers that are inaccessible to shallow-rooted crops. This physiological adaptation, combined with inherent drought tolerance, makes castor a reliable option when early season rains fail and planting is delayed.

198. (D) Maintaining cellular turgor and promoting quick recovery
During a mid-season dry spell, plants experience severe moisture stress, which impairs nutrient uptake and metabolic activity. Applying a foliar spray of two percent urea or potassium chloride provides rapid nutrition. More importantly, it helps maintain cellular turgor by lowering osmotic potential. This physiological support prevents cellular damage, helping the crop survive and recover quickly once rains resume.

199. (B) It retards shoot growth while allowing root growth to limit transpiration
Cycocel, or chlormequat chloride, is a chemical plant growth retardant used to mitigate drought stress. When applied to crops, it temporarily suppresses vegetative shoot elongation and reduces leaf area, which decreases total transpirational water loss. Simultaneously, it allows root development to continue, enabling the plant to maintain a favorable root-to-shoot ratio during moisture deficits.

200. (B) I, III, and IV
Soil water retention is controlled by multiple physical factors. Soil texture dictates the specific surface area available for water adsorption. Soil compaction reduces large macropores, which increases the relative volume of water-retaining capillary pores. Furthermore, due to high adsorptive forces, the permanent wilting point is significantly higher in fine-textured clay soils than in coarse-textured sandy soils.

201. (D) Evapotranspiration and Runoff
The water balance of a catchment basin is modeled using conservation of mass. Input is primarily represented by precipitation. The output components represent water that actually leaves the catchment system. Evapotranspiration, which returns water to the atmosphere, and surface runoff, which drains out of the basin outlet, constitute the primary output pathways in this hydrological balance.

202. (A) Soil water potential
Soil water potential is a fundamental physical term in soil-plant relations. It represents the potential energy status of water in the soil compared to that of pure, free water at the same temperature, elevation, and atmospheric pressure. This potential determines the direction of water movement, as water always flows spontaneously from higher to lower potential states.

203. (B) Field Capacity
While soil physical properties like total porosity and particle density are fixed, field capacity is a dynamic, empirical concept. It represents the soil moisture content remaining after rapid gravitational drainage has ceased, typically two to three days after saturation. Because this drainage rate is influenced by soil profile characteristics, evapotranspiration, and crop water extraction, it is not a constant.

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pressure

2023

9. Capillary action in soils is mathematically best described by which principle?
(A) Fick's Law of diffusion
(B) The Jurin equation
(C) Fourier's Law
(D) Stokes' Law

2017

10. Consider the following statements regarding the energy concepts of soil water:
I. Soil water typically possesses lower potential energy than free pure water at standard pressure.
II. Kinetic energy plays the dominant role in large-scale soil moisture movement compared to potential energy.
III. Differences in potential energy drive the directional movement of water through the soil profile.
Which of the above statements are correct?
(A) I
(B) I and III
(C) II and III
(D) III

2010

11. Which energy state dominates the movement of water through the soil matrix under isothermal conditions?
(A) Potential energy
(B) Radiant energy
(C) Kinetic energy
(D) Heat energy

2003

12. As soil dries, what happens to the potential energy of the remaining soil water?
(A) It increases, becoming more positive
(B) It remains constant until wilting point
(C) It decreases, becoming more negative
(D) It fluctuates based on root respiration

2018

13. The reference state for defining soil water potential is typically pure water at standard atmospheric pressure, a defined elevation, and a specific temperature. What is the potential energy assigned to this reference state?
(A) $100 J/kg$
(B) $-100 kPa$
(C) 1at mosphere
(D) $0 J/kg$

NODIA

2006

14. Which factor significantly alters the kinetic energy of soil water but is generally considered negligible for calculating macroscopic liquid flow?
(A) Elevation above a datum
(B) Soil matric suction
(C) Fluid flow velocity
(D) Solute concentration

2025

15. The force required to remove water from the soil matrix is a reflection of which fundamental concept?
(A) High kinetic energy of soil water
(B) The potential energy difference
(C) High specific heat of solid phase
(D) The latent heat of soil fusion

2023

16. In which situation would the gravitational potential be defined as a negative value?
(A) When the soil water is located above the chosen reference datum
(B) When the soil water is located exactly at the reference datum
(C) Gravitational potential cannot be negative
(D) When the soil water is located below the chosen reference datum

2016

17. The energy status of soil water is often expressed in units of pressure. Which unit is the internationally accepted SI standard for expressing water potential?
(A) Kilopascals (or kPa)
(B) Bars and millibars
(C) Centimeters of water
(D) Standard atmospheres

2025

18. Soil water retention is primarily a function of potential energy derived from which interactions?
(A) Kinetic molecular interactions
(B) Gravitational pull of earth
(C) Adsorption and capillary forces
(D) Aerodynamic boundary resistance

2013

19. Identify the correct statement regarding total soil water potential.
(A) The sum of matric, osmotic, and gravity potentials
(B) The actual volumetric moisture content of the soil
(C) A value that is always positive in unsaturated

CHAPTER 10
Soil Water Relationship

2001

1. Which property of water is primarily responsible for the capillary action observed in soil pores?
(A) Cohesion and adhesion
(B) High specific heat capacity
(C) Osmotic pressure
(D) Low latent heat of vaporization

2001

2. The angle of contact between water and soil particles typically approaches zero. How does this affect the calculation of capillary rise using the capillary tube model?
(A) It reduces the cosine term to zero, minimizing the total calculated rise
(B) It causes the surface tension force to act entirely in a downward vector
(C) It maximizes the cosine term, yielding maximum theoretical capillary rise
(D) It renders the radius of the pore irrelevant to calculating final height

2025

3. What is the fundamental mechanism behind the high surface tension of water in soil physical systems?
(A) Unbalanced cohesive forces at the liquid-gas interface from hydrogen bonding
(B) Strong covalent bonding between hydrogen and oxygen atoms within the molecules
(C) Direct adhesive forces between water molecules and the solid mineral surfaces
(D) Electrostatic repulsion between the positively charged hydrogen atoms in water

2019

4. Identify the INCORRECT statement regarding the polarity of the water molecule.
(A) The bond angle of 104.5° creates an asymmetrical charge distribution
(B) Polarity allows water to act as a universal solvent for ionic soil solutes
(C) High polarity facilitates hydration of exchangeable clay mineral cations
(D) The oxygen atom carries a partial positive charge, and hydrogen is negative

2003

5. In the context of soil physics, cohesion refers to which specific molecular interaction?
(A) The attraction between water molecules and solid soil surfaces
(B) The mutual attraction of water molecules to one another
(C) The binding of water molecules to dissolved ionic solutes
(D) The physical entrapment of water within soil macro-pores

2001

6. Which phenomenon limits the maximum height of capillary rise in coarse sand compared to clay?
(A) High osmotic potential of water in the sand matrix
(B) Lower bulk density of sand compared to clay soils
(C) Larger pore radii that reduce capillary rise force
(D) Higher particle density of sand relative to clay

2002

7. The structural arrangement of water molecules near a clay surface is often described as ice-like. Which factor contributes most to this?
(A) High kinetic energy of molecules at the solid-liquid boundary
(B) High concentration of dissolved oxygen near the clay surface
(C) The presence of soil macropores encouraging crystallization
(D) Adhesive forces restricting translational movement of water

2009

8. Which condition generally decreases the surface tension of soil water?
(A) An increase in temperature and organic solutes
(B) An increase in temperature and inorganic salts
(C) A decrease in soil temperature and total pressure
(D) An increase in dissolved mineral salts and

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(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

51. In irrigation scheduling, the management allowed depletion (MAD) defines the threshold for:
(A) Readily available water
(B) Maximum retentive capacity
(C) Hygroscopic water limit
(D) Permeability coefficient

2014

52. The availability of soil water to plants is heavily dependent on the rate of root extension. This implies that:
(A) Water moves to roots much faster than roots can grow to water
(B) Plant roots remain stationary while gravitational water sustains them
(C) Roots only absorb available soil water from the saturated aquifer
(D) Roots must grow to new zones due to slow unsaturated flow

2007

53. Which term refers to the moisture content at which a specific crop begins to exhibit visible signs of physiological stress?
(A) Maximum retentive capacity
(B) Critical moisture content
(C) Hygroscopic coefficient
(D) Capillary fringe

2011

54. Direct methods of soil moisture determination measure:
(A) The overall matric potential of the soil
(B) The electrical resistance of a porous block
(C) The mass or volume of water in a sample
(D) The high-energy attenuation of gamma rays

2023

55. The standard gravimetric method calculates soil moisture by expressing the mass of water as a percentage of:
(A) The volume of the wet soil
(B) The mass of the wet soil
(C) The total mass of the soil minerals and organic matter combined
(D) The mass of the oven-dry soil

2018

56. What is the standard oven temperature and duration required to achieve constant weight in the gravimetric method for mineral soils?
(A) $105^{\circ}C$ for 24 hours
(B) $60^{\circ}C$ for 12 hours
(C) $150^{\circ}C$ for 4 hours
(D) $200^{\circ}C$ for 1 hour

2023

57. A fresh soil sample weighs $120g$. After oven-drying, it weighs $100g$. What is the gravimetric water content (θ_g)?
(A) 12.0%
(B) 16.6%
(C) 20.0%
(D) 25.0%

2004

58. To convert gravimetric water content (θ_g) to volumetric water content (θ_v), one must multiply θ_g by the ratio of:
(A) Particle density to water density
(B) Soil bulk density to water density
(C) Water density to soil bulk density
(D) Porosity to bulk density

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2012

59. Which sampling tool is highly recommended for accurately determining volumetric water content in the field by taking undisturbed samples?
(A) Core sampler
(B) Soil auger
(C) Hand shovel
(D) Tensiometer

2009

60. Match the soil moisture measurement techniques in List I with their primary operational principles in List II.

List I: (Measurement Technique)
P. Tensiometer
Q. Neutron Moisture Meter
R. TDR
S. Gypsum Block

List II: (Operational Principle)
1. Electrical resistance variation
2. Dielectric constant measurement
3. Thermalization of fast neutrons
4. Equilibration with soil matric potential

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

soils
(D) The work required to overcome gravitational forces

2015
20. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Osmotic potential significantly influences liquid water flow in unsaturated, non-saline soils without root presence.
Reason (R): Osmotic potential arises from the presence of dissolved solutes that lower the free energy of soil water.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023
21. Which component of total water potential is dominant in unsaturated soils above the water table?
(A) Pressure potential
(B) Matric potential
(C) Gravitational potential
(D) Osmotic potential

2013
22. Pressure potential is typically significant and positive under which soil condition?
(A) At soil field capacity
(B) At the wilting point
(C) Below the water table
(D) In dry upper topsoil

2011
23. Why is matric potential always assigned a negative value or zero?
(A) Capillary forces repel soil water molecules
(B) Pore air pressure exceeds atmospheric pressure
(C) Solutes increase the kinetic energy of water
(D) Soil solids lower the energy state of water

2014
24. Which potential relies heavily on semi-permeable membranes to restrict solute movement while allowing water to pass?
(A) Osmotic potential
(B) Matric potential
(C) Gravitational potential
(D) Overburden potential

2016
25. An increase in soil salinity will directly and most profoundly affect which component of soil water potential?
(A) Matric potential
(B) Osmotic potential
(C) Pressure potential
(D) Gravitational potential

2018
26. In highly saturated swelling clay soils, the weight of the overlying soil matrix can influence water energy. This is accounted for by which specific potential?
(A) Matric potential
(B) Overburden potential
(C) Osmotic potential
(D) Kinetic potential

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2003
27. Gravitational potential at a specific point in the soil profile is determined by:
(A) Vertical distance from a reference level
(B) Total volume of liquid water present
(C) Total concentration of dissolved salts
(D) Average radius of individual soil pores

2015
28. How does the pF scale relate to the energy status of soil water?
(A) The negative base-e logarithm of hydraulic conductivity
(B) The concentration of hydrogen ions in the soil solution
(C) The base-10 logarithm of suction head in centimeters
(D) The direct measure of soil moisture percentage by weight

2009
29. A soil sample has a matric suction of $1000\,cm$ of water. What is its approximate pF value?
(A) 1.0
(B) 2.0
(C) 3.0
(D) 4.0

2016
30. Match the soil moisture concepts in List I with their corresponding pF values in List II.
List I: (Soil Moisture Concept)
P. Field Capacity
Q. Permanent Wilting Point
R. Hygroscopic Coefficient

S. Oven Dry Soil

List II: (pF Value)

1. pF 7.0
2. pF 4.5
3. pF 4.18
4. pF 2.53

(A) P-4, Q-3, R-2, S-1
(B) P-4, Q-2, R-3, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-4, S-1

2007

31. Which characteristic curve illustrates the relationship between soil water content and matric potential?
(A) Hydraulic conductivity curve
(B) Soil moisture retention curve
(C) Infiltration capacity curve
(D) Proctor compaction curve

2001

32. In the context of soil moisture characteristic curves, what does the specific yield represent?
(A) Volume of water retained at field capacity
(B) Water extracted by plants before wilting
(C) Tightly bound hygroscopic water content
(D) Water that drains freely under gravity

2022

33. Which soil texture typically exhibits a sudden drop in water content at relatively low suctions on a moisture release curve?
(A) Sandy soil
(B) Heavy clay
(C) Silt loam
(D) Clay loam

2013

34. The phenomenon of hysteresis in soil water refers to:
(A) The lag in soil temperature change deeper in the soil profile
(B) The irreversible structural collapse of soil aggregates upon wetting
(C) Different moisture-potential relations in drying and wetting
(D) The physical failure of tensiometer instruments at high suctions

2023

35. Identify a primary physical cause of hysteresis in soils.
(A) The ink-bottle effect from non-uniform pores
(B) High osmotic potential of the soil solution
(C) Rapid evaporation of water from soil surfaces
(D) Clay flocculation caused by calcium cations

2021

36. For a given matric potential, how does the water content during desorption (drying) compare to sorption (wetting)?
(A) Water content is lower during desorption than sorption
(B) Water content is exactly the same for both phases
(C) It depends exclusively on the soil organic matter content
(D) Water content is higher during desorption than sorption

2010

37. Contact angle hysteresis contributes to the overall hysteresis in the moisture release curve because:
(A) The advancing contact angle is smaller than the receding contact angle
(B) The advancing contact angle is greater than the receding contact angle
(C) Contact angles only exist in perfect capillary tubes
(D) Soil particles drag water during drying

2013

38. The air-entry value or bubbling pressure on a soil moisture retention curve indicates:
(A) Suction at which permanent wilting point is reached
(B) The state where all water is removed from the soil
(C) The suction required to drain the largest soil pores
(D) Suction where plant roots cannot extract more water

2015

39. What is the approximate matric potential threshold defining the Permanent Wilting Point (PWP) for most mesophytic crops?
(A) $-0.33 bar$
(B) $-15 bars$
(C) $-31 bars$
(D) $-10000 bars$

2012

40. Consider the following statements regarding soil moisture constants:
I. Maximum retentive capacity occurs when all soil pores are filled with water.
II. Field capacity is measured immediately after irrigation while gravitational water is still rapidly draining.
III. The ultimate wilting point occurs at a higher suction than the permanent wilting point.

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IV. Hygroscopic water is tightly held and moves primarily in the liquid phase.

Which of the above statements are correct?

(A) I, II
(B) I, III
(C) I, II, IV
(D) II, III, IV

2025

41. Field capacity is typically achieved how long after a heavy rain or irrigation in well-drained loamy soils?

(A) Immediately
(B) 1 to 3 hours
(C) 1 to 3 days
(D) 2 to 3 weeks

2009

42. At field capacity, what is the approximate status of the soil macropores and micropores?

(A) Both pore types are completely filled with liquid water
(B) Macropores are air-filled, micropores are water-filled
(C) Both pore types are completely filled with gaseous air
(D) Macropores are water-filled, micropores are air-filled

2009

43. Which constant is considered the upper limit of plant available water?

(A) Field capacity
(B) Maximum retentive capacity
(C) Permanent wilting point
(D) Hygroscopic coefficient

2016

44. Water held at suctions greater than 31 atmospheres (or $> pF4.5$) is classified as:

(A) Gravitational water
(B) Capillary water
(C) Hygroscopic water
(D) Readily available water

2025

45. The ultimate wilting point is distinguished from the permanent wilting point because at the ultimate wilting point:

(A) Plants can recover if placed in a humid chamber
(B) The matric potential remains exactly $-15 bars$
(C) Free water begins to drain from the crop root zone
(D) Plants will not recover even if water is added

2025

46. Plant Available Water (PAW) is classically defined as the water held between which two constants?

(A) Saturation and Field Capacity
(B) Permanent Wilting Point and Hygroscopic Coefficient
(C) Field Capacity and Permanent Wilting Point
(D) Field Capacity and Hygroscopic Coefficient

2003

47. Which soil textural class typically holds the highest amount of total Plant Available Water (PAW)?

(A) Sand
(B) Silt loam
(C) Heavy clay
(D) Loamy sand

2013

48. Why do heavy clay soils, despite having high porosity, often have lower plant available water than silt loams?

(A) Clays have larger macropores that drain instantly
(B) Clays repel water due to strong hydrophobic forces
(C) Clays have extremely low total mineral surface area
(D) Water is held at suctions beyond the wilting point

NODIA

2017

49. Readily Available Water (RAW) is a fraction of the total available water. It refers to:

(A) The fraction of PAW crops extract without stress
(B) Water held between saturation and field capacity
(C) Water that moves upward via soil capillary action
(D) Water held tightly by the hygroscopic fraction

2008

50. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Clay soils can hold a large total amount of water but may have less plant-available water than silt loams.

Reason (R): In clay soils, the majority of water is held in large macropores that drain rapidly under gravity.

In the light of the above statements, choose the correct answer from the options given below:

204. (A) Soil > Root > Leaf > Atmosphere
Water movement through the soil-plant-atmosphere continuum is driven by a continuous thermodynamic gradient. For water to flow passively upward, the water potential must become increasingly negative along the pathway. Consequently, under active transpiration, the sequence of water potential gradients progresses from the highest in the soil, to the roots, then leaves, and finally the lowest in the atmosphere.

205. (A) Stemflow
Precipitation falling on a forest or crop canopy is partitioned into different pathways. Stemflow refers to the fraction of water that is intercepted by the plant canopy and funneled directly down the branches and main stem. This process concentrates water inputs immediately at the base of the plant, providing highly localized soil moisture recharge.

206. (C) Basic infiltration rate
When measuring water infiltration into a soil over a prolonged period, the rate of water intake initially drops rapidly. As the soil profile becomes saturated and matric suction gradients approach zero, the infiltration rate stabilizes. This constant, minimum rate of water intake under saturated conditions is termed the basic infiltration rate of the soil.

207. (D) It severely restricts downward water movement, causing early ponding
A plow pan is a highly compacted, dense subsurface soil layer formed by repeated tillage at a constant depth. Because compaction destroys continuous macropores, this pan has very low hydraulic conductivity. Consequently, it severely restricts the downward percolation of water. This restriction causes water to pond rapidly above the pan, resulting in early waterlogging and surface runoff.

208. (C) Gypsum
Sodium-dominated soils are prone to aggregate dispersion, which seals surface pores and reduces infiltration. Applying gypsum, or calcium sulfate, resolves this issue. The calcium ions in gypsum displace exchangeable sodium ions on the soil clay complex. This chemical exchange promotes the flocculation of clay particles, improving soil structure, stability, and overall water infiltrability.

209. (B) High Curve Number (e.g., 85)
In the Soil Conservation Service Curve Number method, the Curve Number represents the runoff potential of a catchment. A catchment with highly degraded pasture on heavy clay soil has very low infiltration capacity and high runoff potential. Consequently, this system is assigned a high Curve Number, indicating that a large fraction of rainfall will convert to runoff.

210. (D) Peak flow
A stream hydrograph represents the discharge of a catchment over time in response to a storm event. The peak flow is a critical design parameter that represents the maximum, instantaneous discharge rate achieved during the event. This value is used to design the capacity of hydraulic structures such as spillways, culverts, and flood control channels.

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2008

61. Volumetric water content (θ_v) represents:
(A) The mass of water per unit volume of soil solids
(B) The mass of water per unit mass of wet soil
(C) The volume of water per unit volume of air-filled pores
(D) The volume of water per unit total bulk volume of soil

2009

62. Which is a significant disadvantage of the thermogravimetric method for soil moisture determination?
(A) It requires expensive calibration of nuclear sources
(B) It only measures water potential, not water content
(C) It is destructive, preventing repeat measurements
(D) It is highly sensitive to dissolved soil salinity

2016

63. Indirect methods of soil moisture measurement estimate water content by:
(A) Physically extracting the water via vacuum forces
(B) Measuring a proxy property linked to water content
(C) Weighing the soil before and after intense heating
(D) Calculating the volume of air bubbles in the sample

2012

64. Tensiometers are most effective for measuring soil moisture tension within which operational range?
(A) 0 to $-0.8 bars$
(B) $-1 to -15 bars$
(C) 0 to $-31 bars$
(D) $-15 to -100 bars$

2011

65. What physical limitation causes a tensiometer to fail at suctions greater than approximately 0.8 bars?
(A) Cavitation of the water column occurs
(B) The porous ceramic cup dissolves in water
(C) Liquid water inside the tube freezes solid
(D) The mercury expands beyond the gauge limits

NODIA

2011

66. Electrical resistance blocks (gypsum blocks) are preferred over tensiometers in which specific scenario?
(A) In very wet, saturated soils
(B) In coarse sandy soils requiring high precision at low tension
(C) In drier soils where tension exceeds 1 bar
(D) When highly saline irrigation water is used

2021

67. Why does soil salinity heavily interfere with the accuracy of standard electrical resistance blocks?
(A) Solutes increase conductivity independently of moisture
(B) Salts dissolve the structural gypsum material rapidly
(C) Salts block the block pores, preventing water entry
(D) Salts increase the thermalization rate of neutrons

2005

68. The Neutron Moisture Meter operates based on the principle of thermalization. Which element in the soil is primarily responsible for slowing down the fast neutrons?
(A) Carbon
(B) Oxygen
(C) Nitrogen
(D) Hydrogen

2001

69. A major limitation of using a Neutron Moisture Meter near the soil surface (top 15-20 cm) is:
(A) High interference from incoming cosmic rays
(B) Escape of fast neutrons into the atmosphere
(C) Excessive organic matter trapping the probe
(D) Rapid dissolution of the radioactive source

2015

70. Consider the following statements regarding Time-Domain Reflectometry (TDR):
I. TDR measures the bulk dielectric permittivity of the soil.
II. The dielectric constant of water is roughly 80, whereas dry soil minerals are between 3 to 5.
III. TDR measurements are highly sensitive to soil temperature and entirely insensitive to bulk density.
IV. TDR requires a site-specific calibration curve for every single measurement.
V. TDR probes determine moisture by measuring the travel time of an electromagnetic pulse.
Which of the above statements are INCORRECT?

(A) I, II, V
(B) I, III, IV
(C) II, IV, V
(D) III, IV

2012

71. Which property of water makes Time-Domain Reflectometry (TDR) highly effective for moisture determination?
(A) Low electrical conductivity
(B) High specific heat capacity
(C) High refractive index value
(D) High dielectric constant

2017

72. Which instrument is often used as an alternative to TDR, utilizing an oscillator to measure the capacitance of the soil-water-air mixture?
(A) Frequency Domain Reflectometry (FDR)
(B) High-precision vacuum tensiometer
(C) Standard pressure plate apparatus
(D) Gas-flow displacement pycnometer

2017

73. When computing equivalent depth of water (D_w) in a soil layer of thickness Z, which formula is used?
(A) $D_w = \theta_g \times Z$
(B) $D_w = \theta_v \times Z$
(C) $D_w = \dfrac{\text{Bulk Density}}{\theta_v} \times Z$
(D) $D_w = \dfrac{\text{Porosity} \times Z}{\theta_g}$

2012

74. A 20 cm deep soil layer has a volumetric water content of 25%. What is the equivalent depth of water in this layer?
(A) 5 mm
(B) 25 mm
(C) 50 mm
(D) 500 mm

2025

75. Soil moisture depletion is calculated to determine:
(A) The water needed to reach field capacity
(B) The exact timing of the next rainfall event
(C) Deep percolation losses below the root zone
(D) The potential rate of upward capillary rise

2011

76. If a soil has a field capacity of 30% (volumetric) and current moisture of 15% (volumetric) in a 40 cm root zone, the net irrigation requirement to reach field capacity is:
(A) $15mm$
(B) $40mm$
(C) $60mm$
(D) $120mm$

2014

77. Profile water storage capacity is determined by evaluating:
(A) The total amount of hygroscopic water stored throughout the profile
(B) The combined volume of macropores and micropores in the profile
(C) The maximum possible infiltration rate measured at the soil surface
(D) The sum of equivalent water depths across all root-zone horizons

2024

78. Which parameter is essential for converting gravimetric water content to an equivalent depth of water?
(A) Soil temperature
(B) Matric potential
(C) Bulk density
(D) Solute concentration

2018

79. The actual volume of water available to a crop depends strongly on the depth of the root zone. A shallow-rooted crop in a deep loamy soil will primarily suffer water stress because:
(A) The soil has low profile water storage capacity
(B) It can only access a fraction of profile water
(C) Capillary rise prevents downward root growth
(D) Deep soil profiles always have poor soil aeration

2016

80. Select the correct sequence for calculating the irrigation water requirement based on soil moisture data.
(A) Measure current θ_v → Subtract FC → Divide by bulk density → Multiply by root depth
(B) Calculate root depth → Measure FC → Measure PWP → Add current moisture
(C) Measure bulk density → Convert FC to θ_g → Subtract current depth → Multiply by area
(D) Measure current θ_g → Convert to θ_v → Calculate equivalent depth → Subtract from equivalent depth at FC

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2012
81. In the context of hydraulic head dynamics, elevation head (z) represents:
(A) Potential energy from position above a reference
(B) The static pressure exerted by a column of water
(C) The kinetic energy of water moving downward in soil
(D) The energy consumed by viscous friction in soil pores

2008
82. The total hydraulic head (H) in a saturated soil system is mathematically defined as the sum of:
(A) Osmotic head and matric head
(B) Velocity head and kinetic head
(C) Pressure head and elevation head
(D) Matric head and osmotic head

2005
83. Hydraulic gradient, which is the driving force for water flow, is defined as:
(A) The change in hydraulic head per unit distance
(B) The total hydraulic head divided by the time
(C) The difference between elevation head and pressure head
(D) The cross-sectional area divided by the flow rate

2004
84. In an unsaturated soil, what replaces the positive pressure head in the total hydraulic head equation?
(A) Osmotic potential head
(B) Overburden pressure head
(C) Fluid velocity head
(D) Matric suction head

2001
85. If water flows vertically downward from point A to point B in a saturated soil column, what must be true about the hydraulic heads at these points?
(A) Total head at A is equal to total head at B
(B) Total head at A is greater than total head at B
(C) Total head at A is less than total head at B
(D) Pressure head at A must be greater than pressure head at B

2016
86. At the exact surface of a free water table, the pressure head (h) is:
(A) Positive and equal to the aquifer depth
(B) Highly negative due to soil matric forces
(C) Atmospheric pressure, defined as zero
(D) Exactly equal to the local elevation head

2005
87. Under conditions of hydrostatic equilibrium (no water movement), the total hydraulic head throughout the soil profile is:
(A) Zero
(B) Constantly increasing with depth
(C) Constantly decreasing with depth
(D) Constant at all depths

NODIA

2012
88. In an unsaturated profile under hydrostatic equilibrium, the matric potential head at a height z above the water table is:
(A) $+z$
(B) $-z$
(C) Zero

2024
89. Darcy's law states that the flux density (q) of water in a porous medium is proportional to:
(A) The square root of the hydraulic gradient
(B) The hydraulic gradient
(C) The cross-sectional area only
(D) The inverse of the hydraulic conductivity

2025
90. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Darcy's law, in its modified form (the Buckingham-Darcy equation), is applicable to unsaturated soil water flow.
Reason (R): Unsaturated hydraulic conductivity remains constant as soil water content decreases.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006
91. The proportionality constant in Darcy's Law ($q = -K \cdot \frac{\Delta H}{L}$) is denoted as K. What does K represent?
(A) Saturated conductivity
(B) Kinetic flow coefficient
(C) Intrinsic permeability
(D) Hydraulic diffusivity

2002

169. What is the fundamental principle behind drop structures or check dams in gully control?
(A) To increase the kinetic energy of water flowing rapidly in the deep gully system
(B) To permanently store all surface runoff water for livestock and human drinking
(C) To significantly increase the total sediment transport capacity of the flow
(D) To reduce the gully channel gradient and dissipate flowing water energy

2001

170. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The use of organic mulch effectively reduces water erosion.
Reason (R): Mulch intercepts raindrops, dissipating their kinetic energy before they detach soil particles.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) Both A and R are false.

2010

171. The USLE ($A = RKLSCP$) predicts:
(A) The exact quantitative amount of sediment delivered directly to a nearby river
(B) Long-term average annual sheet and rill erosion from a field slope
(C) The absolute severity and physical propagation of deep gully erosion channels
(D) The estimated wind erosion rates and dust transport during the dry season

2018

172. Tillage practices that leave at least 30% of the soil surface covered by crop residues after planting are classified as:
(A) Clean tillage
(B) Conservation tillage
(C) Conventional deep inversion tillage
(D) Primary tillage

2019

173. Under the RUSLE (Revised Universal Soil Loss Equation), improvements were made to the C factor. What does the C factor represent?
(A) Cover-management factor
(B) Climate erosivity
(C) Conservation support practices
(D) Clay content

2005

174. Which of the following represents an inherent, largely unchangeable soil factor affecting erosion (as opposed to management factors)?
(A) The total vegetative cover percentage over the year
(B) The presence of physical engineering terracing systems
(C) Inherent soil texture and profile depth
(D) The direction of contour tillage operations

2008

175. Why is a stable soil aggregate structure crucial for minimizing soil erodibility?
(A) It dramatically decreases the water infiltration rate in the topsoil
(B) It significantly increases the physical specific gravity of soil minerals
(C) It consistently creates a perfectly smooth and flat soil surface texture
(D) It resists water slaking and dispersion, reducing detachment

2024

176. Which cation, when dominating the soil exchange complex, heavily promotes clay dispersion and massively increases soil erodibility?
(A) Calcium (Ca^{2+})
(B) Magnesium (Mg^{2+})
(C) Sodium (Na^{+})
(D) Aluminum (Al^{3+})

2004

177. A soil with poor aeration typically suffers from restricted root growth because of:
(A) Excessive atmospheric oxygen levels causing severe direct root toxicity
(B) Accumulation of toxic gases like ethylene and hydrogen sulfide
(C) High levels of easily available nitrogen compounds in the soil
(D) Extremely low bulk density and high mechanical soil impedance

2004

178. The Oxygen Diffusion Rate (ODR) is a critical parameter for soil aeration. Below what approximate ODR value is root growth of most crops severely inhibited?
(A) $20 \times 10^{-8} gcm^{-2}\text{min}^{-1}$
(B) $100 \times 10^{-8} gcm^{-2}\text{min}^{-1}$
(C) $1 \times 10^{-2} gcm^{-2}\text{min}^{-1}$
(D) $0 gcm^{-2}\text{min}^{-1}$

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2019

103. Why does unsaturated hydraulic conductivity drop precipitously as a soil dries?
(A) Air bubbles increase the viscosity of the remaining water
(B) Soil particles physically expand and block internal pores
(C) The effective gravitational constant decreases with dryness
(D) Water must flow through smaller, tortuous pore paths

2011

104. Which soil texture generally has a higher hydraulic conductivity at a relatively high tension (e.g., $-1 bar$), despite having a lower saturated hydraulic conductivity?
(A) Clay
(B) Sand
(C) Loamy sand
(D) Coarse gravel

2002

105. Hydraulic diffusivity (D) in unsaturated flow is mathematically defined as the ratio of:
(A) Matric suction head to unsaturated conductivity
(B) Hydraulic conductivity to specific water capacity
(C) Gravitational potential to overall matric potential
(D) Saturated conductivity to unsaturated conductivity

2025

106. The Richards equation, used to describe transient water flow in unsaturated soils, is derived from combining Darcy's law with which fundamental physical principle?
(A) The continuity equation (mass conservation)
(B) The First Law of Thermodynamics (energy conservation)
(C) Newton's Second Law of Motion (momentum conservation)
(D) The ideal gas law (state equation for gases)

2004

107. When water moves from a finer-textured soil layer into an underlying coarse sandy layer, what typically happens at the interface?
(A) Water instantly drains into the sand
(B) Water movement halts until the fine soil becomes nearly saturated
(C) The sand acts as a capillary wick pulling water down
(D) Water moves laterally, creating a perched water table that permanently ignores the sand

2013

108. Why does a coarse sandy layer beneath a loam act as a barrier to unsaturated downward flow?
(A) Sand has a higher matric suction than loam under typical dry field conditions
(B) Large pores empty at low suction, reducing its unsaturated conductivity
(C) Sand physically repels water molecules due to hydrophobic silica bonds on the surface
(D) Sand has a much lower total porosity that completely prevents initial water entry

2013

109. Which gradient is the primary driver of water vapor transport in soils?
(A) Vapor pressure gradient
(B) Matric suction gradient
(C) Elevation gradient
(D) Gravitational gradient

2011

110. Consider the following statements regarding vapor phase transport:
I. Vapor flow is highly significant in saturated soils.
II. Vapor movement occurs from regions of high vapor pressure to low vapor pressure.
III. Temperature gradients are a major driver of vapor pressure differences in soils.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II, and III

2017

111. How does soil temperature influence water vapor movement?
(A) Vapor moves from cooler areas to warmer areas
(B) Temperature has no effect on vapor transport
(C) Vapor movement completely stops at temperatures above $30^{\circ} C$
(D) Vapor moves from warmer areas to cooler areas

2006

112. The transport of water vapor in soils is typically modeled using:
(A) Poiseuille's Law of capillary flow
(B) The classical Bernoulli equation
(C) Fick's Law of diffusion
(D) The Manning open-channel equation

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2024
113. Mass flow of water vapor in the soil profile is relatively minor compared to diffusion. When it does occur, it is usually driven by:
(A) Solute concentration gradients within the localized soil solution
(B) Barometric pressure changes and soil air expansion
(C) Capillary rise of liquid water from a shallow water table
(D) Root exudates altering the surface tension of soil water

2004
114. Vapor transport becomes the dominant mechanism of water movement in soils only when:
(A) The soil is at field capacity with optimal crop water availability
(B) The soil is continuously saturated with water under positive pressure
(C) The soil is subjected to heavy rainfall or intensive flood irrigation
(D) The soil is extremely dry, below the permanent wilting point

2016
115. Which phenomenon explains the observation of moist surface soil in desert environments during the early morning hours, despite no rainfall?
(A) Upward vapor transport condensing in cooler surface soils overnight
(B) Rapid capillary rise of liquid water from extremely deep regional aquifers
(C) Hydraulic descent and active transport of water by deep-rooted plants
(D) Intense solar evaporation from the highly porous surface soil layer

2013
116. Soil irrigability classification evaluates the suitability of land for sustained irrigation. Which physical factor is a primary criterion?
(A) Atmospheric relative humidity and air temperature
(B) Net solar radiation and average day length
(C) Soil profile permeability and drainage
(D) Ambient wind speed and boundary layer resistance

2023
117. In the land capability classification for irrigation, Class 1 lands are characterized by:
(A) Deep, well-drained soils with high water capacity and no limitations
(B) Severe topography with extreme slopes requiring extensive mechanical leveling
(C) Extremely shallow soils with high salinity and low nutrient retention
(D) High exchangeable sodium percentages requiring intensive chemical amendments

2005
118. Which topographic feature presents the most severe limitation for surface irrigation methods, lowering the irrigability class?
(A) Flat agricultural slopes with gradient less than one percent
(B) Mild undulating terrain with moderate surface drainage
(C) Immediate physical proximity to an active irrigation canal
(D) Steep slopes and irregular micro-relief

2012
119. A soil with an extremely low saturated hydraulic conductivity (e.g., dense clay pan) is classified as having poor irrigability primarily because of:
(A) Low nutrient retention and rapid leaching of essential minerals
(B) High risk of waterlogging and poor root aeration
(C) Excessive deep percolation losses below the active root zone
(D) High risk of wind erosion during dry fallow periods

2008
120. Consider the following steps for determining a field water budget:
I. Calculate changes in soil moisture storage
II. Measure or estimate actual evapotranspiration
III. Quantify inputs (precipitation and irrigation)
IV. Measure losses like runoff and deep percolation
Which of the following represents the correct sequence of these steps?
(A) III → IV → II → I
(B) I → II → III → IV
(C) IV → III → II → I
(D) II → I → IV → III

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2013
121. The general field water budget equation over a time period t can be expressed as: $\Delta S = P + I - R - D - ET$. What does D represent?
(A) Dew formation
(B) Drainage ditch capacity
(C) Day length
(D) Deep percolation

2001

122. Surface runoff (R) in the water budget equation is initiated when:
(A) Precipitation rate exceeds the infiltration capacity
(B) Evapotranspiration exceeds total precipitation inputs
(C) Deep percolation ceases entirely in the lower profile
(D) Soil surface temperature drops below the air dew point

2001

123. Which component of the field water budget is often the most difficult to measure directly and is frequently calculated as the residual of the budget equation?
(A) Total measured precipitation input
(B) Deep percolation and seepage
(C) Controlled artificial irrigation input
(D) Initial volumetric soil moisture content

2009

124. When calculating the field water budget for a rice paddy, which subsurface flux becomes a major, dominating loss component?
(A) Upward vapor diffusion
(B) Percolation and seepage
(C) Capillary rise from groundwater
(D) Surface runoff and overflow

2011

125. Subsurface water fluxes are governed heavily by the depth to the water table. Capillary rise is beneficial for crop growth only if:
(A) The water table is deep enough to avoid waterlogging but shallow enough to reach roots
(B) The water table is located exactly at the soil surface, causing continuous and severe flooding
(C) The water table is highly saline and contains elevated levels of dissolved salts
(D) The water table is greater than 10 meters deep, preventing any upward movement

2024

126. Deep percolation represents water moving downward out of the root zone. Agronomically, why is limited deep percolation sometimes necessary in irrigated arid regions?
(A) To deliberately increase the local water table height
(B) To transport applied fertilizers down into deeper aquifers
(C) To leach accumulated salts out of the root zone
(D) To significantly cool the deeper subsoil layers of the field

2012

127. Evapotranspiration (ET) combines which two distinct processes?
(A) Infiltration of water into the soil profile and physical evaporation
(B) Transpiration from leaves and deep percolation into shallow groundwater
(C) Surface runoff across the field and initial infiltration into the soil
(D) Evaporation from the soil and transpiration from the plant canopy

2009

128. Potential Evapotranspiration (PET) assumes:
(A) The soil profile is kept at the permanent agricultural wilting point
(B) Stomatal closure of vegetation during periods of peak solar radiation
(C) An unrestricted supply of water to the evaporating surfaces
(D) High atmospheric relative humidity suppressing all physical evaporation

2007

129. Reference Evapotranspiration (ET_o) standardizes the ET estimate based on a reference crop. What is the internationally accepted standard reference crop surface?
(A) A bare, recently tilled loam soil field maintained under dry conditions
(B) A well-watered, actively growing short grass of uniform height
(C) A mature maize field with a fully closed canopy and deep root system
(D) A free water pan of standard dimensions exposed to the atmosphere

2022

130. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Actual Evapotranspiration (AET) is always equal to Potential Evapotranspiration (PET).
Reason (R): Plants transpire at maximum rates regardless of the soil moisture content.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

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(D) Both A and R are false.

2016
131. Crop Evapotranspiration (ET_c) under standard conditions is calculated by multiplying the Reference Evapotranspiration (ET_o) by:
(A) The crop coefficient (K_c)
(B) The leaf area index (LAI)
(C) The pan evaporation coefficient (K_p)
(D) The soil heat flux (G)

2004
132. During the initial growth stage of a row crop, which component of total ET is generally dominant?
(A) Plant transpiration
(B) Snow sublimation
(C) Surface evaporation
(D) Soil vapor transport

2011
133. The Penman-Monteith equation is the FAO standard for calculating ET_o. Which physical parameters are explicitly required for this calculation?
(A) Radiation, air temperature, wind speed, and humidity
(B) Soil texture class, bulk density, and saturated infiltration rate
(C) Gravitational potential gradient and localized matric suction value
(D) Soil organic carbon percentage and cation exchange capacity (CEC)

2002
134. Which mechanism of action correctly describes how organic mulches reduce soil-surface evaporation?
(A) They increase the soil surface temperature, drying out the topsoil rapidly
(B) They physically block capillary liquid water rise directly from the water table
(C) They increase the localized wind speed at the soil surface boundary layer
(D) They act as a barrier, reducing vapor transport and heat flux

2013
135. Synthetic plastic mulches, particularly black polyethylene, manage soil water by:
(A) Absorbing atmospheric moisture and actively transferring it into the soil
(B) Acting as an impermeable barrier to water vapor loss from the soil
(C) Increasing the evaporation rate of soil water through micro-perforations
(D) Reflecting incoming solar radiation to keep the soil profile extremely cool

2003
136. Conservation tillage practices, such as no-till, enhance soil moisture retention primarily by:
(A) Breaking up the subsoil hardpan to dramatically increase deep percolation
(B) Inverting the entire soil profile to bring wet soil directly to the surface
(C) Leaving crop residues on the surface to reduce runoff
(D) Deliberately increasing the bare surface area exposed directly to the sun

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2004
137. Which of the following is NOT a recognized category of anti-transpirants?
(A) Stomata-closing chemicals
(B) Film-forming emulsions
(C) Reflectant physical materials
(D) Cuticle-dissolving

2008
138. Phenylmercuric acetate (PMA) and abscisic acid (ABA) are examples of which type of anti-transpirant?
(A) Stomata-closing
(B) Film-forming
(C) Reflectant
(D) Growth retardant

2002
139. Film-forming anti-transpirants (e.g., silicone oils, waxes) work by:
(A) Reflecting incoming solar radiation to significantly lower leaf surface temperature
(B) Creating a physical barrier over stomata that restricts water vapor loss
(C) Inducing rapid chemical closure of the guard cells surrounding the stomata
(D) Increasing the internal osmotic potential of the absorbing plant root cells

2010
140. Match the anti-transpirant type (List I) with its corresponding example/mechanism (List II):
List I: Anti-transpirant type
P. Stomata-closing
Q. Film-forming
R. Reflectant
S. Growth retardant
List II: Example/mechanism
1. Kaolin clay
2. Phenylmercuric acetate
3. Cycocel (CCC)

4. Mobil leaf / Waxes
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-1, Q-3, R-4, S-2
(D) P-2, Q-1, R-4, S-3

2008

141. Reflectant anti-transpirants, such as Kaolin, reduce transpiration by:
(A) Increasing leaf albedo to reduce leaf temperature and vapor gradient
(B) Blocking the internal xylem vessels to restrict upward water movement in stems
(C) Chemically forcing the leaf stomata to close during active daylight
(D) Reducing root surface area and overall capacity for soil water uptake

2006

142. A significant disadvantage of using film-forming anti-transpirants is that they:
(A) Severely increase the plant transpiration rate during overnight hours
(B) Cause the active roots of the crop to rot due to anaerobic conditions
(C) Can restrict CO_2 diffusion, thereby reducing photosynthesis
(D) Increase the surrounding soil temperature drastically during the day

2006

143. Windbreaks (shelterbelts) conserve crop canopy water primarily by:
(A) Shading the entire agricultural crop field surface from incoming shortwave solar radiation
(B) Increasing turbulent mixing of air masses directly above the crop canopy
(C) Trapping high atmospheric humidity and condensing it as artificial rainfall
(D) Decreasing wind velocity to increase boundary layer thickness and reduce vapor loss

2017

144. The effective zone of protection provided by a windbreak on the leeward side is generally proportional to:
(A) The physical width and dense horizontal thickness of the windbreak structure
(B) The specific taxonomic species of trees used, regardless of their height
(C) The height of the windbreak (H), protecting up to 15-20 H leeward
(D) The deep root penetration depth and underground anchoring of the windbreak

2017

145. An increase in soil bulk density (compaction) generally leads to:
(A) A significant increase in total porosity and soil water holding capacity
(B) A decrease in total porosity and an increase in mechanical impedance
(C) A marked increase in macroporosity and overall gaseous diffusion rate
(D) A drastic decrease in soil thermal conductivity and heat storage capacity

2013

146. High mechanical impedance in soils prevents root extension. Roots typically struggle to penetrate soils when the penetrometer resistance exceeds:
(A) Less than $0.1 MPa$
(B) Around $0.5 MPa$
(C) $2.0 - 3.0 MPa$
(D) Greater than $10.0 MPa$

2017

147. Soil aeration relies primarily on gas diffusion through air-filled pores. At what volumetric air-filled porosity does restricted aeration typically begin to severely limit root growth for most mesophytic crops?
(A) 1%
(B) 10%
(C) 30%
(D) 50%

2007

148. How does water content affect the thermal conductivity of a soil?
(A) It decreases thermal conductivity by replacing mineral solids with liquid water
(B) It has absolutely no measurable physical effect on soil thermal regimes
(C) It increases conductivity because water conducts heat better than air
(D) It causes the soil surface to reflect almost all incoming solar radiation

2013

149. Why do wet soils typically warm up more slowly in the spring compared to dry soils?
(A) Water has a high specific heat, requiring more energy to raise its temperature
(B) Wet soils inherently possess a much lower specific heat capacity compared to dry soils
(C) Wet soils are generally lighter in color and reflect more solar radiation

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2017
92. Which soil property primarily determines the saturated hydraulic conductivity ($K_{\{sat\}}$)?
(A) Soil profile color
(B) Sand fraction mineralogy
(C) Pore size distribution
(D) Soil chemical pH value

2016
93. Based on Poiseuille's Law, the flow rate through a cylindrical pore is proportional to the radius of the pore raised to which power?
(A) Second power (r^2)
(B) Third power (r^3)
(C) Fourth power (r^4)
(D) First power (r)

2016
94. Identify the factor that does NOT significantly affect the saturated hydraulic conductivity of a soil.
(A) Overall soil texture
(B) Structural aggregation
(C) Atmospheric CO_2 levels
(D) Liquid fluid viscosity

2006
95. Infiltration refers to:
(A) The movement of water through the deeper soil profile
(B) The entry of water into the soil surface
(C) The upward movement of water via capillary action
(D) The lateral surface flow of water

2011
96. During a constant-intensity rainfall event, the infiltration rate typically:
(A) Starts very low and increases over time
(B) Remains completely constant during the event
(C) Fluctuates randomly depending on wind speed
(D) Starts high and decreases to a steady rate

2003
97. The steady-state infiltration rate achieved after prolonged wetting is roughly equal to:
(A) Saturated conductivity of the limiting horizon
(B) The total porosity value of the surface soil
(C) The rainfall intensity, regardless of soil type
(D) The maximum possible water retentive capacity

2013
98. Percolation differs from infiltration in that percolation describes:
(A) The initial entry of water into the soil surface
(B) The thermodynamic conversion of water to vapor
(C) Downward water movement through the soil profile
(D) The lateral surface runoff and ponding process

2022
99. Which equation is widely used to model the empirical decline of infiltration rate over time?
(A) Horton's equation
(B) Penman-Monteith equation
(C) Stokes' Law
(D) Fick's Law

2008
100. Match the flow types in List I with their defining driving gradients in List II.
List I: (Flow Type)
P. Saturated Flow
Q. Unsaturated Flow
R. Vapor Flow
S. Osmotic Flow
List II: (Driving Gradient)
1. Solute concentration gradient
2. Vapor pressure gradient
3. Positive pressure and elevation gradients
4. Matric suction and elevation gradients
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-2, R-4, S-1

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2025
101. In unsaturated soil water flow, the driving force includes elevation head and:
(A) Positive pressure head
(B) Matric suction head
(C) Osmotic head only
(D) Velocity head

2024
102. How does hydraulic conductivity behave in an unsaturated soil ($K(\theta)$)?
(A) It remains constant regardless of moisture content
(B) It increases significantly as soil water dries out
(C) It decreases rapidly as soil moisture decreases
(D) It only depends on the temperature of soil water

(A) Only deep-rooted trees planted in long windbreak rows
(B) Active agricultural crops in vertical strips directly down the slope
(C) A single uniform monoculture crop across the entire field area
(D) Alternating bands of close-growing crops and row crops

2023
160. Choose the correct sequence of water erosion stages.
(A) Transport → Detachment → Deposition
(B) Detachment → Transport → Deposition
(C) Deposition → Detachment → Transport
(D) Transport → Deposition → Detachment

2012
161. Vegetative barriers (e.g., Vetiver grass hedges) planted on the contour control erosion by:
(A) Deliberately increasing the kinetic velocity of all surface runoff water
(B) Filtering suspended sediment and slowing runoff, forming terraces over time
(C) Completely eliminating rainfall erosivity before it reaches the soil surface
(D) Completely preventing any liquid water from moving downward along the slope

2008
162. Mechanical/engineering measures for erosion control are typically required when:
(A) The agricultural field slope is less than two percent on average
(B) The soil profile is completely flat but possesses highly permeable sands and gravels
(C) The vegetative crop canopy is completely closed during all seasons of the year
(D) Agronomic measures alone are insufficient on steep slopes with high rainfall

2010
163. Bunding is a mechanical erosion control measure involving the construction of small embankments. Contour bunding is most suitable for areas with:
(A) Low rainfall ($< 600mm$) and permeable soils to conserve moisture
(B) High rainfall ($> 1000mm$) and steep terrains with highly erodible soils
(C) Heavy, dense clay soils that are naturally prone to severe seasonal waterlogging
(D) Highly sensitive riverbanks to completely prevent major localized flooding

2019
164. In regions with high rainfall where safe disposal of excess runoff is required, which type of bunding is preferred over contour bunding?
(A) Peripheral bunding
(B) Zero bunding
(C) Graded bunding
(D) Earthen dams

2011
165. Bench terracing converts a steep slope into a series of level or nearly level steps. It is generally recommended for slopes ranging from:
(A) 1% to 3%
(B) 3% to 6%
(C) 16% to 33%
(D) $> 50\%$

2009
166. Broad Bed and Furrow (BBF) systems are agronomic/engineering land configurations designed primarily to:
(A) Effectively prevent severe wind erosion in dry sandy desert regions
(B) Deliberately maximize the physical K-factor of the agricultural soil
(C) Artificially increase physical water evaporation losses from fields
(D) Manage drainage in heavy clay soils while conserving moisture

2005
167. Which of the following is a primary characteristic of a graded terrace?
(A) It perfectly follows the geographic contour line with absolutely no physical slope
(B) It has a slight longitudinal slope to guide excess water to a waterway
(C) It is specifically designed to retain all incident rainfall without any surface drainage
(D) It is exclusively used for wetland rice cultivation in highly saturated conditions

2006
168. Grassed waterways are engineered channels that are seeded with suitable grass species. Their primary purpose in an erosion control plan is to:
(A) Maximize soil water infiltration and completely prevent water from leaving the field boundaries
(B) Serve as a dense vegetative windbreak to reduce local horizontal wind speed
(C) Safely transport concentrated runoff down the slope without gully erosion
(D) Act as the primary physical reservoir and main source of irrigation water

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(D) Water creates an insulating high-vacuum layer within the soil macropores

2003

150. Consider the following statements regarding soil erodibility:

I. Erodibility refers to the susceptibility of soil particles to detachment and transport.
II. Sandy soils are highly cohesive and thus the least erodible of all textures.
III. Silt and very fine sand fractions are highly susceptible to water erosion.
IV. High soil organic matter generally reduces soil erodibility.

Which of the above statement(s) is/are correct?

(A) I, II, III
(B) I, III, IV
(C) II, III, IV
(D) I, IV

2002

151. In the Universal Soil Loss Equation (USLE), $A = R \times K \times LS \times C \times P$, what does the K-factor represent?

(A) Rainfall erosivity factor
(B) Soil erodibility factor
(C) Topographic factor
(D) Conservation practice factor

2017

152. Which soil textural class typically exhibits the highest K-factor (most erodible) in the USLE?

(A) Heavy clay
(B) Coarse sand
(C) Silt loam
(D) Loamy sand

2021

153. Why are clayey soils often less erodible than silty soils, despite having smaller individual particles?

(A) Individual clay particles are significantly heavier than those of silt
(B) Clay-dominated soils exhibit much higher saturated infiltration rates
(C) Clay soils possess mineral properties that completely repel water
(D) Clay soils possess cohesive forces that promote stable aggregation

2018

154. Profile permeability affects soil erodibility primarily by:

(A) Influencing infiltration rate, which determines surface runoff volume
(B) Altering the physical color and organic matter content of the topsoil
(C) Changing the chemical pH and ionic strength of incoming rainfall
(D) Increasing the average kinetic energy and velocity of falling raindrops

NODIA

2023

155. Which nomograph is historically used to estimate the USLE K-factor based on soil properties?

(A) The standard Penman-Monteith empirical nomograph
(B) Wischmeier's erodibility nomograph
(C) Darcy's saturated permeability reference chart
(D) The USDA soil textural classification triangle

2005

156. Consider the following erosion control strategies:

I. Bench terracing
II. Strip cropping
III. Contour farming

Which of the following represents the correct sequence for selecting these strategies based on slope steepness (from flattest to steepest terrain)?

(A) I → II → III
(B) III → II → I
(C) II → III → I
(D) III → I → II

2012

157. Agronomic measures for erosion control primarily function by:

(A) Providing vegetative cover to intercept rain and slow runoff
(B) Modifying the physical slope of the land to reduce steepness
(C) Constructing solid concrete barriers across primary waterways
(D) Diverting excess surface water into deep subsurface tile drains

2004

158. Contour farming reduces soil erosion primarily by:

(A) Completely eliminating the agronomic need for physical soil tillage
(B) Deliberately increasing the physical slope length of the farmland
(C) Creating small surface ridges that catch and retain runoff water
(D) Concentrating excess water into vertical gullies for rapid drainage

2011

159. Strip cropping involves planting:

2017
179. Soil temperature directly influences seed germination. The concept of "base temperature" refers to:
(A) The minimum temperature below which germination ceases
(B) The optimum physical temperature for the fastest possible seed germination
(C) The absolute maximum temperature before cellular seed mortality occurs
(D) The specific temperature measured exactly at the bare soil surface

2001
180. Match the physical soil factors (List I) with their direct effect on plant development (List II):
List I: Physical soil factors
P. High bulk density
Q. Low soil temperature
R. Low matric potential
S. Low air-filled porosity
List II: Direct effect on plant development
1. Reduced water uptake due to high suction
2. Reduced nutrient and water uptake due to hypoxia
3. Increased mechanical impedance to root extension
4. Delayed seed germination and slow root metabolism
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2021
181. What is the impact of a very low soil temperature on root water uptake?
(A) It decreases uptake due to higher water viscosity and lower membrane permeability
(B) It significantly increases uptake rates due to lower liquid water viscosity in cold conditions
(C) It has absolutely no direct physiological effect on root water uptake
(D) It causes the plant roots to actively and continuously expel water

2017
182. Soil thermal diffusivity governs how rapidly temperature changes penetrate the soil profile. It is defined as:
(A) Volumetric heat capacity multiplied by bulk density
(B) Solar radiation minus longwave emission
(C) The difference between maximum and minimum daily temperature
(D) Thermal conductivity divided by volumetric heat capacity

2019
183. In a typical diurnal soil temperature profile, the maximum temperature at a depth of 15 cm occurs:
(A) Exactly at solar noon (12:00 PM) when radiation is highest
(B) Simultaneously with the absolute maximum surface temperature
(C) Several hours after surface maximum due to thermal lag
(D) Exactly at midnight when the ambient air is at its coolest

2024
184. The damping depth of daily temperature fluctuations in soil represents:
(A) The average depth of the seasonal water table beneath the soil surface
(B) The physical depth where active root growth permanently and completely ceases due to stress
(C) The depth where the temperature wave amplitude is reduced to 37% of its surface value
(D) The compact depth of the hard plow pan layer created by tillage

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2022
185. High bulk density often signifies soil compaction. For a loamy soil, what bulk density threshold typically restricts root growth?
(A) $0.9 \frac{g}{cm^3}$
(B) $1.1 \frac{g}{cm^3}$
(C) $1.3 \frac{g}{cm^3}$
(D) $1.6 \frac{g}{cm^3}$

2016
186. Compaction primarily reduces the volume of which type of soil pores?
(A) Macropores (aeration pores)
(B) Micropores (capillary pores)
(C) Intrapedal pores
(D) Cryptopores

2022
187. "Hardpan" formations in soil profiles adversely affect plant development by:
(A) Significantly increasing the total water

storage capacity of topsoils
(B) Restricting root penetration and causing temporary waterlogging
(C) Providing a rich subterranean reservoir of easily available oxygen gas
(D) Accelerating down-profile leaching of vital soluble nutrients

2021
188. According to Penman's empirical relation for gas diffusion in soils, the ratio of the soil gas diffusion coefficient (D_s) to the free-air diffusion coefficient (D_0) is primarily a linear function of which parameter?
(A) Soil bulk density
(B) Air-filled porosity
(C) Saturated hydraulic conductivity
(D) Soil organic matter content

2008
189. Organic matter addition improves soil physical conditions for plant growth by:
(A) Promoting aggregation, increasing porosity, and lowering bulk density
(B) Increasing physical bulk density and overall thermal conductivity of dry soils
(C) Significantly decreasing soil aggregation and increasing plastic deformability
(D) Completely preventing downward water infiltration and surface runoff pathways

2009
190. Consider the following statements regarding soil physics and plant growth:
I. Optimum seed-soil contact is necessary for adequate moisture transfer to the seed.
II. Extreme soil temperatures denature root enzymes.
III. Soil aeration is independent of water content.
IV. Mechanical impedance decreases as soil dries due to shrinkage.
V. Compaction increases the volumetric heat capacity of the soil.
Which of the above statement(s) is/are INCORRECT?
(A) I, II, V
(B) III, IV
(C) II, III, V
(D) III, IV, V

2021
191. Water retention in the soil matrix is enhanced by:
(A) Decreasing the overall organic matter content of the topsoil
(B) Increasing the relative proportion of structural macropores
(C) Subjecting the entire field to extensive soil compaction
(D) Increasing clay and organic matter content

2004
192. Which soil texture holds the maximum total water at saturation but may not provide the most plant-available water?
(A) Coarse sand
(B) Medium loam
(C) Heavy clay
(D) Silt loam

2010
193. The phenomenon where wet clay soils shrink and crack upon drying contributes to:
(A) Decreased infiltration rates during intense initial rain events
(B) Rapid bypass flow of water into deep soils
(C) Complete elimination of all structural aeration macropores
(D) Significantly decreased mechanical impedance to root extension

2009
194. Frost heaving, a process highly destructive to plant roots, occurs primarily in soils with:
(A) High gravel content with large air-filled macropores and low water storage
(B) Very low moisture content preventing any frozen physical volume expansion
(C) Extreme physical compaction limiting the movement of subsoil water upward
(D) High silt content and a shallow water table supplying capillary water

2021
195. Which thermal property dictates the amount of energy required to raise the temperature of a unit volume of soil by one degree?
(A) Volumetric heat capacity
(B) Soil thermal conductivity
(C) Soil thermal diffusivity
(D) Latent heat of vaporization

2010
196. Agronomic measures are generally the first line of defense against erosion because they:
(A) Permanently alter the local physical topography of the entire field
(B) Require heavy and expensive mechanical earth-moving construction machinery
(C) Are cheaper and protect the soil surface from rainsplash

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(D) Involve the intensive application of synthetic chemical soil sealants

2023

197. The structural stability of soil aggregates against rainfall impact can be tested in the laboratory using:
(A) Wet sieving analysis
(B) The standard soil hydrometer method
(C) A high-pressure plate extractor
(D) A calibrated subsurface neutron probe

2007

198. Conservation agriculture relies on three main principles to conserve soil and water. Which is NOT one of them?
(A) Minimum mechanical soil disturbance
(B) Permanent organic soil cover
(C) Species diversification (crop rotations)
(D) Deep inversion plowing annually

2019

199. Cover crops, when incorporated into a crop rotation, reduce erosion primarily by:
(A) Increasing the physical bulk density of the vulnerable topsoil layer
(B) Providing vegetative cover during otherwise fallow periods
(C) Extracting almost all available soil water from the root profile
(D) Decreasing soil organic matter content and aggregate stability

2010

200. Consider the following statements regarding erosion control structures:
I. Check dams are utilized to stabilize gully beds.
II. Contour bunds are small embankments built across the slope.
III. Terraces reduce the effective slope length.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II, and III

2013

201. Which type of terrace is constructed with a level channel and a ridge, designed primarily for moisture conservation in low-rainfall areas?
(A) Standard graded terrace
(B) Traditional bench terrace
(C) Conservation Zingg terrace
(D) Level absorption terrace

2007

202. The ratio of the volume of water retained at field capacity to the volume of water at saturation provides a rough estimate of:
(A) The percentage of microporosity
(B) The percentage of macroporosity
(C) The permanent wilting point
(D) The saturated hydraulic conductivity

2011

203. Which parameter limits the usefulness of a gypsum block in highly responsive irrigation scheduling?
(A) Its extremely high sensitivity to small tension changes
(B) Its slow response time to moisture changes
(C) Its total inability to measure suction values beyond 0.5 bars
(D) Its massive physical size that severely disrupts the root zone

2007

204. Consider the following statements regarding soil water potential components:
I. Total potential is primarily the sum of matric and osmotic potentials in well-drained, unsaturated, non-saline field soils.
II. Gravitational potential is positive below the reference datum.
III. Osmotic potential is critical for defining mass flow of liquid water in saturated soils.
IV. Pressure potential is zero above the free water table.
Which of the above statement(s) is/are INCORRECT?
(A) I, IV
(B) II, III
(C) I, II, III
(D) III, IV

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2024

205. In a soil profile with a textural discontinuity (sand over clay), infiltration is governed by:
(A) The clay layer permeability once the wetting front reaches it
(B) The absolute permeability of the sand layer indefinitely under all conditions
(C) The local ambient atmospheric pressure acting upon the soil surface
(D) The upward capillary physical pull generated within the coarse sand

2015

206. Anisotropy in soil hydraulic conductivity refers to:
(A) Hydraulic conductivity remaining exactly

The permanent wilting point occurs near pF four point one eight. The hygroscopic coefficient is measured at pF four point five, and oven-dry soil reaches a theoretical suction of pF seven point zero.

31. (B) Soil moisture retention curve
The relationship between soil water content and matric potential is plotted using the soil moisture retention curve. This characteristic release curve is fundamental to soil physics, as it illustrates how tightly water is held by a particular soil texture across a range of moisture contents, defining key hydraulic behaviors and plant-available water boundaries.

32. (D) Water that drains freely under gravity
In hydrology and soil physics, specific yield is defined as the volume of water that saturated soil will yield when drained by gravity. It represents the active drainage of macropores immediately after saturation. The remaining soil water, which is held against gravity by capillary and adhesive forces, is referred to as the specific retention capacity.

33. (A) Sandy soil
Sandy soils are dominated by large macropores with uniform, wide pore radii. According to capillary principles, these large pores release their stored water at very low matric suctions. Consequently, the soil moisture release curve for sandy profiles shows a steep, sudden drop in water content as soon as a small suction is applied to the system.

34. (C) Different moisture-potential relations in drying and wetting
Hysteresis describes the path-dependent nature of the soil moisture characteristic curve. It means that the relationship between soil water content and matric potential is not unique, but depends on whether the soil is drying out or wetting up. At any given matric potential, a drying soil retains a higher water content than a wetting soil.

35. (A) The ink-bottle effect from non-uniform pores
A primary physical cause of hysteresis is the ink-bottle effect, which arises from the non-uniformity of soil pores. These pores feature narrow necks and wide bodies. During drying, water drainage is restricted by the small radius of the neck. During wetting, water entry is controlled by the larger radius of the body, leading to path-dependent differences.

36. (D) Water content is higher during desorption than sorption
For any specific matric potential, the water content of a soil is consistently higher during desorption than during sorption. This occurs because emptying a pore during drying is restricted by its narrowest passage, while filling a pore during wetting is controlled by its widest section, resulting in the characteristic hysteretic lag in soil moisture relationships.

37. (B) The advancing contact angle is greater than the receding contact angle
Contact angle hysteresis occurs because the liquid-solid contact angle varies depending on whether the water front is moving forward or backward. The advancing contact angle of water on a dry soil surface is systematically larger than the receding contact angle on a wet surface. This discrepancy shifts the capillary force calculations and contributes to hysteretic behavior.

38. (C) The suction required to drain the largest soil pores
The air-entry value represents the specific matric suction at which air first begins to penetrate into a completely saturated soil matrix. This threshold corresponds to the suction required to overcome capillary forces and drain the largest pores. Beyond this pressure point, water content starts to decrease actively as air displaces liquid from these macro-pores.

39. (B) $-15 bars$
The permanent wilting point is a key soil moisture constant representing the lower limit of water availability to plants. By standard agronomic convention, this threshold is defined at a matric potential of minus fifteen bars. At this extreme suction, mesophytic crops can no longer extract water fast enough to offset transpiration losses, causing irreversible wilting in the field.

40. (B) I and III
Statement one is correct because maximum retentive capacity represents complete saturation where all pores are water-filled. Statement three is correct since the ultimate wilting point occurs at higher suctions than the permanent wilting point, causing permanent crop death. Statement two is incorrect because field capacity

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ANSWERS

1. (A) Cohesion and adhesion
Capillary action in soil pores is driven by the combined effects of cohesive and adhesive forces. Cohesion refers to the mutual attraction between water molecules, which maintains liquid continuity. Adhesion represents the attraction between water and solid soil surfaces. Together, these forces allow water to rise against gravity within the narrow pore spaces of the soil profile.

2. (C) It maximizes the cosine term, yielding maximum theoretical capillary rise
In the capillary rise equation, the height of water rise is directly proportional to the cosine of the contact angle between the liquid and solid. When this contact angle approaches zero, its cosine reaches its maximum value of one. Consequently, this relationship maximizes the calculated upward force, yielding the highest possible theoretical capillary height in soil pores.

3. (A) Unbalanced cohesive forces at the liquid-gas interface from hydrogen bonding
High surface tension in soil water systems arises from the asymmetrical attraction experienced by water molecules at the boundary with air. Molecules within the bulk liquid are pulled equally in all directions by hydrogen bonds. However, those at the surface lack upward neighbors, creating a net inward pull that minimizes surface area and forms a strong, elastic-like skin.

4. (D) The oxygen atom carries a partial positive charge, and hydrogen is negative
Water is a polar molecule due to the high electronegativity of oxygen relative to hydrogen. This difference causes shared electrons to spend more time near the oxygen atom, which acquires a partial negative charge. Conversely, the hydrogen atoms carry partial positive charges. This uneven charge distribution creates a permanent dipole, which is essential for key soil physical interactions.

5. (B) The mutual attraction of water molecules to one another
Cohesion is the intermolecular attraction existing between identical substances, which in soil physics specifically refers to the attraction of water molecules to one another. This force is driven by hydrogen bonding between the partially positive hydrogen atoms and partially negative oxygen atoms of adjacent water molecules, enabling the formation of continuous liquid columns inside soil pore spaces.

6. (C) Larger pore radii that reduce capillary rise force
The height of capillary rise in soils is inversely proportional to the radius of the pore spaces, as defined by the Jurin equation. Coarse sand consists of large particles that form wide pores with large radii, which significantly decreases the upward capillary force. In contrast, clay has highly compact micro-pores that generate much higher capillary tension and vertical rise.

7. (D) Adhesive forces restricting translational movement of water
Near clay surfaces, strong adhesive forces restrict the translational and rotational freedom of water molecules. Negative charges on clay mineral surfaces attract the positive poles of water dipoles, aligning them in a highly ordered, rigid configuration. This restricted mobility mimics the crystalline lattice of ice, altering the physical properties of water near the solid phase.

8. (A) An increase in temperature and organic solutes
Surface tension is a function of intermolecular cohesive forces within water. Raising the temperature increases the kinetic energy of water molecules, which weakens hydrogen bonds and decreases surface tension. Additionally, the presence of organic solutes, such as surfactants or dissolved organic matter, interferes with water-water interactions at the liquid-gas interface, further lowering the surface tension of soil solution.

9. (B) The Jurin equation
The Jurin equation mathematically describes capillary action by calculating the height of liquid rise in a capillary tube. It relates the rise height to liquid surface tension, contact angle, fluid density, acceleration due to gravity, and tube radius. In soil physics, this classical equation

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equal in all physical measurement directions
(B) Soil hydraulic conductivity steadily increasing with increases in ambient temperature
(C) Conductivity varying depending on flow direction (e.g., vertical vs. horizontal)
(D) Hydraulic conductivity ceasing completely as soil dries to the permanent wilting point

2022

207. Consider the following statements related to Evapotranspiration (ET):
I. Actual ET can exceed Potential ET under severe drought conditions.
II. Reference ET (ET_o) is calculated independent of crop type.
III. The crop coefficient (K_c) varies dynamically with the crop growth stage.
IV. Transpiration relies on a vapor pressure deficit between the leaf interior and the atmosphere.
V. Wind heavily suppresses the rate of ET by cooling the leaves.
Which of the above statement(s) is/are INCORRECT?
(A) I, V
(B) II, III, IV
(C) I, IV, V
(D) I, II, V

2023

208. The capillary fringe is defined as the zone:
(A) Deep within the regional saturated aquifer where water is purely under positive hydrostatic pressure
(B) Directly at the bare soil surface during periods of extremely high-intensity rainfall events
(C) Immediately above the water table where soil is nearly saturated under negative pressure
(D) In the moisture range bounded between the field capacity and agricultural permanent wilting point

2023

209. Measuring the electrical conductivity (EC) of a soil extract is primarily done to assess:
(A) Soil matric potential under unsaturated conditions
(B) Salinity, which relates to osmotic potential
(C) Gravitational potential relative to a deep reference datum
(D) Long-term soil structural stability and aggregate integrity

2022

210. Consider the following soil moisture states:
I. Field Capacity
II. Saturation
III. Hygroscopic Coefficient
IV. Permanent Wilting Point
Which of the following represents the correct sequence of these states from the highest energy state (least tightly bound) to the lowest energy state (most tightly bound)?
(A) II → I → IV → III
(B) I → II → III → IV
(C) II → IV → I → III
(D) III → IV → I → II

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20. (D) A is false but R is true.
The assertion is incorrect because osmotic potential does not significantly drive bulk liquid water flow unless a semi-permeable membrane, such as a root membrane, is present. In bulk soil pores, solutes move freely with water without creating pressure gradients. However, the reason is correct because dissolved solutes restrict water's freedom, thereby lowering its potential energy state.

21. (B) Matric potential
In unsaturated soils located above the water table, matric potential is the dominant component of total water potential. This potential is generated by the combined action of capillary forces in narrow pores and adsorptive forces on particle surfaces. It is always negative and increases in magnitude as the soil dries, controlling water retention and movement.

22. (C) Below the water table
Below the water table, the soil is completely saturated, and water exists under positive hydrostatic pressure. This hydrostatic head is directly proportional to the depth below the water table surface. Therefore, the pressure potential is positive and significant in saturated zones, whereas it is zero at the water table and negative in unsaturated soils above it.

23. (D) Soil solids lower the energy state of water
Matric potential represents the attractive forces between water molecules and soil solids, consisting of capillary and adsorptive mechanisms. Because these forces bind water molecules to soil particle surfaces and within pores, they restrict their physical freedom and lower their potential energy relative to free pure water. Consequently, matric potential must be negative or zero.

24. (A) Osmotic potential
Osmotic potential is driven by the concentration of dissolved solutes in soil water. For this potential to generate physical pressure gradients or drive water movement, a semi-permeable membrane must separate solutions of differing concentrations. This membrane restricts solute passage while permitting water to flow, as observed across root cell membranes during nutrient and water uptake.

25. (B) Osmotic potential
Soil salinity refers to the concentration of dissolved mineral salts within the soil solution. Because osmotic potential is directly determined by the concentration of these dissolved ions, an increase in salinity lowers the free energy of soil water. This change makes the osmotic potential significantly more negative, which restricts the ability of plants to extract water.

26. (B) Overburden potential
In swelling clay soils, the weight of the overlying soil matrix and any external load exerts physical pressure on the water within the saturated pores. This pressure increases the potential energy of the soil water. This specific effect is mathematically defined as the overburden potential, which is highly significant in deep, poorly drained clay profiles.

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27. (A) Vertical distance from a reference level
Gravitational potential energy depends solely on the vertical elevation of soil water relative to a selected reference datum. Mathematically, it is calculated as the product of the acceleration due to gravity and the vertical distance from the reference level. It is completely independent of soil properties like pore size, salinity, or water content.

28. (C) The base-10 logarithm of suction head in centimeters
The pF scale is a logarithmic index used to simplify the wide numerical range of soil water tension. It is defined as the common base-10 logarithm of the soil matric suction head expressed in centimeters of water. This scale allows large physical suctions to be represented by small, manageable numbers ranging typically from zero to seven.

29. (C) 3.0
The pF value of soil water is calculated by taking the base-10 logarithm of the matric suction head measured in centimeters of water. For a suction head of one thousand centimeters, the common logarithm is three. Therefore, this level of soil water suction corresponds to a pF value of exactly three on the standard logarithmic scale.

30. (A) P-4, Q-3, R-2, S-1
Soil moisture constants have specific equivalent pF values. Field capacity corresponds to a suction of approximately pF two point five three.

of coarse-textured sandy soils rather than heavy-textured clay profiles in agricultural settings.

51. (A) Readily available water
In irrigation management, the management allowed depletion defines the maximum fraction of plant available water that is permitted to be depleted before irrigation must be applied. This operational threshold corresponds directly to the boundary of readily available water, ensuring that soil moisture levels do not drop to a point that induces crop water stress under field conditions.

52. (D) Roots must grow to new zones due to slow unsaturated flow
Because unsaturated hydraulic conductivity is extremely low, water in dry soils moves toward roots at a very slow pace. To survive and sustain transpiration, plants cannot rely solely on the capillary movement of water. Instead, active root extension is necessary, allowing roots to continually explore and extract from new, moist soil volumes.

53. (B) Critical moisture content
The critical moisture content represents the specific soil water level below which a crop can no longer meet its transpiration demands, leading to physiological stress. At this point, the rate of water absorption falls behind potential transpiration, causing stomata to close and visible symptoms like wilting or reduced growth rates to appear in the agricultural field.

54. (C) The mass or volume of water in a sample
Direct methods of soil moisture determination involve the physical extraction and quantitative measurement of the actual water contained within a soil sample. This is accomplished by weighing the sample before and after removing the water via oven-drying. These direct measurements yield absolute values of either mass-based or volume-based soil water content directly.

55. (D) The mass of the oven-dry soil
The standard gravimetric method determines soil water content on a mass basis. It calculates the percentage of moisture by dividing the mass of water lost during drying by the final mass of the oven-dry soil. Using dry soil mass as the baseline ensures a stable, unchanging reference value regardless of fluctuating soil moisture levels.

56. (A) $105^{\circ}C$ for 24 hours
In the standard thermogravimetric method for mineral soils, samples are placed in a ventilated oven maintained at one hundred and five degrees Celsius for twenty-four hours. This temperature is sufficient to drive off all free, capillary, and weakly adsorbed water without causing the thermal decomposition of soil organic matter or structural clay minerals within the sample.

57. (C) 20.0%
Gravimetric water content is calculated by dividing the mass of water by the mass of dry soil, expressed as a percentage. In this case, the mass of water is twenty grams, which is the fresh weight minus the dry weight. Dividing twenty grams by the dry weight of one hundred grams yields exactly twenty percent.

58. (B) Soil bulk density to water density
To convert gravimetric water content to volumetric water content, the gravimetric value is multiplied by the ratio of soil bulk density to the density of water. This mathematical adjustment accounts for the dry mass per unit bulk volume of the soil matrix, allowing mass-based measurements to be translated into actual field water volumes.

59. (A) Core sampler
Determining volumetric water content requires preserving the original bulk density and structure of the soil. A core sampler is highly recommended because it extracts an undisturbed soil volume of known dimensions. This allows researchers to accurately measure both the water mass and the total bulk volume, which is impossible with disruptive augers or shovels in the field.

60. (B) P-4, Q-3, R-2, S-1
Various soil moisture instruments operate on distinct physical principles. Tensiometers equilibrate directly with matric potential. The neutron moisture meter relies on the thermalization of fast neutrons by hydrogen. Time-domain reflectometry measures the dielectric constant of the bulk soil, and gypsum resistance blocks utilize variations in electrical resistance to estimate soil moisture levels.

61. (D) The volume of water per unit total bulk volume of soil
Volumetric water content is a key physical parameter defined as the ratio of liquid water

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is measured after rapid gravitational drainage ceases, not during the drainage process.

41. (C) 1 to 3 days
In well-drained loamy soils, field capacity is typically reached one to three days after a saturating rain or irrigation. During this period, the rapid downward movement of gravitational water through larger macropores slows down to a negligible rate. The remaining water is held inside micropores by matric forces, establishing a temporary, stable equilibrium status.

42. (B) Macropores are air-filled, micropores are water-filled
At field capacity, gravity has drained water from the larger pores because capillary forces in them are too weak to resist downward pull. Consequently, macropores become air-filled, providing critical aeration for root respiration. However, micropores possess strong capillary forces that retain water against gravity, meaning they remain completely filled with liquid water for plant use.

43. (A) Field capacity
Field capacity is defined as the upper limit of plant-available water. It represents the maximum amount of water that a soil can retain against the downward force of gravity after excess water has drained away. Any water present above this limit drains too rapidly through macropores to be effectively utilized by growing agricultural crops.

44. (C) Hygroscopic water
Water held at suctions exceeding thirty-one atmospheres is designated as hygroscopic water. This category of soil water exists as extremely thin films tightly bound to particle surfaces by strong electrostatic adhesive forces. Because this water is held at such immense suctions, plant roots cannot extract it, and it moves primarily in the soil vapor phase.

45. (D) Plants will not recover even if water is added
The ultimate wilting point represents a highly critical moisture threshold. At the permanent wilting point, wilted plants can still recover turgidity if placed in a saturated atmosphere or irrigated. However, once the soil dries to the ultimate wilting point, the physical dehydration of plant cells is complete and irreversible, preventing recovery even if water is added to the soil.

46. (C) Field Capacity and Permanent Wilting Point
Plant available water is defined as the portion of soil water that can be readily absorbed by crop roots. This reservoir is bounded by field capacity as the upper limit, where gravitational drainage ceases, and the permanent wilting point as the lower limit, where matric suction prevents extraction. This range is critical for managing irrigation planning.

47. (B) Silt loam
Silt loam soils typically exhibit the highest capacity to store plant available water. Unlike sandy soils, which drain too rapidly due to large pores, or heavy clays, which lock water within micropores at suctions beyond the wilting point, silt loams feature an optimal balance of medium-sized pores that retain substantial water at low suctions in the field.

48. (D) Water is held at suctions beyond the wilting point
Heavy clay soils possess high total porosity, but their pore space is dominated by extremely small micropores. These micropores exert immense capillary and adsorptive forces on water. Consequently, a massive proportion of the stored water is bound at suctions exceeding fifteen bars, making it completely unavailable for plant root uptake during dry conditions.

49. (A) The fraction of PAW crops extract without stress
Readily Available Water represents the fraction of total plant available water that crops can absorb easily without experiencing physiological water stress. As soil dries, extracting the remaining water requires plants to expend excessive energy. Irrigation managers target this readily accessible reservoir to schedule water applications before crop transpiration rates begin to decline and yield suffers.

50. (C) A is true but R is false.
The assertion is correct because clay soils hold high total water but bind a vast portion of it too tightly in micropores for plant extraction. However, the reason is false because clays are dominated by micropores, not macropores. Rapid gravitational drainage is a characteristic

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is used as a model to represent capillary water movement through cylindrical soil pores.

10. (B) I and III
Soil water potential energy is typically lower than that of pure, free water at the same temperature and pressure, rendering it negative. Furthermore, spatial gradients in this potential energy provide the primary driving force that dictates the direction of water movement. Kinetic energy is generally negligible because the actual velocity of water flow in soils is extremely slow.

11. (A) Potential energy
Under isothermal conditions, water movement within the soil matrix is driven almost entirely by gradients in potential energy. Kinetic energy is negligible because the velocity of water flow in soils is extremely low. Thus, the differences in potential energy per unit quantity of water from one point to another dictate the rate and direction of soil water movement.

12. (C) It decreases, becoming more negative
As soil moisture content decreases, the remaining water is held within smaller pores and closer to particle surfaces where adhesive and cohesive forces are exceptionally strong. This restriction significantly reduces the free energy of water compared to the reference state of pure free water. Consequently, the matric potential decreases, moving toward increasingly negative values as the soil dries out.

13. (D) $0 J/kg$
By international convention, the potential energy of the reference state is defined as zero. This reference state consists of pure, free water with no dissolved solutes, located at a specified elevation, under standard atmospheric pressure, and at a constant temperature. The water potential at any point in the soil is measured relative to this baseline value of zero.

14. (C) Fluid flow velocity
Fluid flow velocity directly determines the kinetic energy of water. However, under typical field conditions, water movement through the soil matrix occurs at extremely slow rates, often measured in millimeters or centimeters per day. Because the resulting kinetic energy is so tiny relative to gravitational and matric potential energies, it is neglected in macroscopic flow equations like Darcy's law.

15. (B) The potential energy difference
The force required to extract water from soil is determined by the potential energy difference between soil water and free water. Soil water is bound by capillary and adsorptive forces, placing it in a lower energy state than free water. Removing this water requires performing work to overcome this energy deficit and raise its potential to zero.

16. (D) When the soil water is located below the chosen reference datum
Gravitational potential energy depends on the position of water relative to a selected reference elevation. If the water is situated above the datum, its potential is positive. Conversely, when water is located below this reference elevation, work must be performed to raise it back to the datum level, resulting in a negative gravitational potential value.

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17. (A) Kilopascals (or kPa)
The international SI unit for measuring pressure and energy per unit volume is the pascal. In soil physics and environmental sciences, water potential is most commonly expressed in kilopascals or megapascals. These standard units represent the force exerted per unit area, allowing researchers to quantify and compare soil water tension consistently across global studies.

18. (C) Adsorption and capillary forces
Soil water retention in unsaturated matrices is governed by matric forces, which are comprised of adsorption and capillarity. Adsorption occurs because solid particle surfaces attract polar water molecules through electrostatic forces. Capillarity arises from surface tension and contact angles within narrow pore channels. Together, these interactions reduce the potential energy of soil water, keeping it retained.

19. (A) The sum of matric, osmotic, and gravity potentials
Total soil water potential represents the sum of several individual energy components that act upon soil water. These primary components include matric potential, which describes surface interactions; osmotic potential, which accounts for dissolved solutes; and gravitational potential, which is based on elevation relative to a datum. This combined value dictates water movement under field conditions.

volume to the total bulk volume of the soil sample. The total bulk volume includes the volume of solid mineral particles, organic matter, and all air-filled and water-filled pore spaces, providing a realistic measure of soil water storage.

62. (C) It is destructive, preventing repeat measurements
The thermogravimetric method requires physically extracting soil cores and heating them in an oven to remove moisture. Because this sampling process completely destroys the soil structure in the sampled area, it is impossible to perform repeat, non-destructive measurements at the exact same physical location over time to monitor continuous soil moisture dynamics.

63. (B) Measuring a proxy property linked to water content
Indirect methods of determining soil moisture estimate the water content by measuring a secondary physical or chemical property of the soil that correlates predictably with moisture. These proxy properties include electrical resistance, dielectric permittivity, or thermal properties, allowing non-destructive monitoring of soil water status without physical soil extraction or standard oven-drying procedures.

64. (A) 0 to $-0.8 bars$
Tensiometers are designed to measure soil water matric potential in wet to moderately dry ranges, typically between zero and minus zero point eight bars. Within this range, water flows freely through the porous ceramic cup, maintaining hydrostatic tension equilibrium between the instrument reservoir and the surrounding soil matrix under field conditions.

65. (A) Cavitation of the water column occurs
At suctions exceeding approximately zero point eight bars, the negative pressure inside the tensiometer tube exceeds the cohesive strength of the water. This causes cavitation, where dissolved gases bubble out of solution and form air pockets. This vapor gap breaks the hydraulic continuity of the water column, rendering the physical pressure gauge completely inoperable.

66. (C) In drier soils where tension exceeds 1 bar
Gypsum blocks are preferred over tensiometers in drier soils where matric potential falls below minus one bar. While tensiometers fail at these suctions due to cavitation, electrical resistance blocks can measure soil moisture tension from one bar down to fifteen bars, spanning the majority of the plant-available soil water range in drylands.

67. (A) Solutes increase conductivity independently of moisture
Electrical resistance blocks operate by correlating the electrical resistance of a porous material with soil water content. Dissolved salts dramatically increase the electrical conductivity of the soil solution. This high ion concentration decreases the measured electrical resistance independently of the actual moisture content, leading to highly inaccurate, overestimated soil moisture readings in the field.

68. (D) Hydrogen
The neutron moisture meter emits fast neutrons into the soil. When these neutrons collide with elements of similar mass, they lose kinetic energy and slow down, a process called thermalization. Hydrogen is the only common soil element with a mass nearly identical to a neutron, making it uniquely effective at slowing them down inside the profile.

69. (B) Escape of fast neutrons into the atmosphere
Using a neutron probe near the soil surface presents a severe limitation because fast neutrons escape into the atmosphere instead of colliding with hydrogen atoms in the soil. This escape prevents proper thermalization, leading to an underestimation of slow neutron counts and introducing significant errors in surface zone soil moisture content calculations.

70. (D) III, IV
Statements three and four are incorrect because Time-Domain Reflectometry is actually highly sensitive to soil bulk density, which alters the dielectric properties of the solid phase. Furthermore, TDR is known for its general calibration independence, meaning that standard universal calibration equations can be applied to most mineral soils without requiring site-specific curves.

71. (D) High dielectric constant
Time-Domain Reflectometry relies on the high dielectric constant of water, which is approximately eighty at room temperature. In contrast, dry soil minerals have a dielectric constant between three and five, while air is

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thermal water vapor transfer under dry field conditions.

112. (C) Fick's Law of diffusion
Subsurface gas transport is a highly diffusion-dominated process. The movement of water vapor through the air-filled pore spaces of unsaturated soils is mathematically described and modeled using Fick's Law of diffusion. This law states that the rate of diffusion is directly proportional to the concentration gradient of the vapor between different soil zones.

113. (B) Barometric pressure changes and soil air expansion
While diffusion is the dominant mechanism for water vapor movement in soils, mass flow can occur under specific environmental conditions. This convective transport is primarily driven by fluctuations in barometric pressure and the thermal expansion or contraction of soil air, which physically forces air and vapor mixtures through the open pore network.

114. (D) The soil is extremely dry, below the permanent wilting point
Liquid water movement ceases when soils dry past the permanent wilting point because liquid pathways become discontinuous. At this extremely low moisture content, the matric potential is very low, and capillary flow is negligible. Consequently, vapor transport becomes the primary and dominant mechanism for any remaining water movement within the soil profile.

115. (A) Upward vapor transport condensing in cooler surface soils overnight
Desert soils experience significant diurnal temperature fluctuations. During the night, the soil surface cools rapidly while deeper layers remain warmer. This temperature gradient causes water vapor to move upward from the warmer subsoil to the cooler surface. Upon reaching the cold surface soil, the vapor condenses, resulting in observable morning moisture.

116. (C) Soil profile permeability and drainage
Evaluating land for sustained irrigation requires assessing physical soil properties to prevent long-term degradation. Soil profile permeability and internal drainage are primary criteria in soil irrigability classification. These factors determine how easily applied water moves through the profile, directly influencing the risk of waterlogging, salinization, and root zone aeration problems.

117. (A) Deep, well-drained soils with high water capacity and no limitations
Land capability classification systems categorize soil suitability for sustained agricultural production under irrigation. Class 1 lands represent the highest quality agricultural soils. These soils are characterized by deep profiles, excellent drainage, high water-holding capacity, and smooth topography. They possess no significant physical or chemical limitations, requiring minimal special management practices.

118. (D) Steep slopes and irregular micro-relief
Topography dictates the feasibility and efficiency of surface irrigation systems. Steep slopes and irregular micro-relief present severe physical limitations. They cause uneven water distribution, excessive runoff, and severe soil erosion. Consequently, fields with these features are placed in lower irrigability classes and generally require sprinkler or drip systems instead of surface methods.

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119. (B) High risk of waterlogging and poor root aeration
A dense clay pan or highly impermeable subsoil layer restricts the downward movement of water. This extremely low saturated hydraulic conductivity prevents adequate drainage, leading to water accumulation in the root zone. The resulting waterlogging excludes oxygen from the soil pores, causing poor root respiration and severely restricting plant growth.

120. (A) III → IV → II → I
Determining a field water budget involves a systematic sequence of calculations. First, researchers quantify all incoming water inputs like precipitation and irrigation. Second, they measure outbound water losses such as runoff and deep percolation. Third, they estimate actual evapotranspiration losses. Finally, these values are synthesized to calculate the changes in soil moisture storage.

121. (D) Deep percolation
The field water budget equation accounts for all water additions, losses, and storage changes within the root zone over a given timeframe. In this mass balance equation, the term represented

calculating total hydraulic head and driving flow gradients.

82. (C) Pressure head and elevation head
In saturated soil systems, the total hydraulic head is defined as the sum of the positive pressure head and the elevation head. The positive pressure head represents the hydrostatic pressure exerted by overlying water, while the elevation head accounts for position relative to a datum. Together, these two heads govern saturated water flow.

83. (A) The change in hydraulic head per unit distance
The hydraulic gradient is the fundamental driving force for soil water movement. It is defined as the change in total hydraulic head per unit of distance along the direction of water flow. This gradient represents the spatial rate of energy loss, with water always flowing from zones of higher hydraulic head to lower hydraulic head.

84. (D) Matric suction head
In unsaturated soils, the positive hydrostatic pressure head is replaced by the matric suction head, which represents negative pressure. This negative pressure is generated by capillary and adsorptive forces holding water within unsaturated pores. Consequently, the total hydraulic head in these systems becomes the sum of the elevation head and the negative matric suction head.

85. (B) Total head at A is greater than total head at B
Water movement in soils is always driven by gradients in potential energy, flowing from regions of higher total hydraulic head to regions of lower total hydraulic head. For vertical downward flow to occur from point A to point B, the total hydraulic head at point A must exceed the total hydraulic head at point B in the system.

86. (C) Atmospheric pressure, defined as zero
The water table is defined as the planar boundary separating the saturated zone below from the unsaturated zone above. At this exact interface, the water is in direct equilibrium with atmospheric pressure. Therefore, by standard convention in soil physics, the hydrostatic pressure head at the surface of the water table is defined as exactly zero under atmospheric pressure.

87. (D) Constant at all depths
Hydrostatic equilibrium represents a state of balance where no net movement of water occurs within the soil profile. Because water flow is driven solely by spatial differences in total hydraulic head, a lack of water movement mathematically requires the hydraulic gradient to be zero, meaning the total hydraulic head must be constant at all depths.

88. (B) $-z$
Under hydrostatic equilibrium, the total hydraulic head is constant throughout the profile, and is equal to zero if the water table is the reference datum. At a height z above this datum, the elevation head is positive z. To maintain a constant total head of zero, the matric potential head must equal negative z value.

89. (B) The hydraulic gradient
Darcy's law is the fundamental governing equation for water flow through porous media under saturated conditions. It states that the flux density, which represents the volume of water flowing through a unit area per unit time, is directly proportional to the hydraulic gradient. This linear relationship is governed by the saturated soil hydraulic conductivity.

90. (C) A is true but R is false.
The assertion is correct because the Buckingham-Darcy equation successfully extends Darcy's law to unsaturated flow by defining hydraulic conductivity as a function of water content. However, the reason is false because unsaturated hydraulic conductivity is highly variable, dropping rapidly by several orders of magnitude as soil dries and water is restricted to smaller soil pores.

91. (A) Saturated conductivity
In the classical expression of Darcy's Law for saturated porous media, the constant of proportionality K represents the saturated hydraulic conductivity. This parameter is a physical measure of the soil's ability to transmit water when all of its pore spaces are completely filled with liquid, reflecting inherent soil structural and textural properties.

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one. This immense contrast allows TDR to precisely estimate volumetric soil water content by measuring electromagnetic pulse travel times through the soil matrix.

72. (A) Frequency Domain Reflectometry (FDR)
Frequency Domain Reflectometry is widely used as a reliable alternative to Time-Domain Reflectometry. This instrument utilizes an electrical oscillator to apply a high-frequency radio signal to soil-inserted probes. By measuring the resonant frequency of the circuit, FDR determines the bulk capacitance, which is directly linked to the bulk soil dielectric permittivity and volumetric water content.

73. (B) $D_w = \theta_v \times Z$
The equivalent depth of water in a soil layer represents the height of a liquid water sheet if all moisture were extracted. It is mathematically calculated by multiplying the dimensionless volumetric water content by the total thickness of the soil layer. This conversion is crucial for evaluating root-zone water storage in irrigation scheduling depth calculations.

74. (C) 50 mm
To find the equivalent water depth, the volumetric water content is multiplied by the layer thickness. Multiplying twenty-five percent, or zero point twenty-five, by twenty centimeters yields an equivalent water depth of five centimeters. Converting this length into standard agricultural units yields exactly fifty millimeters of water stored within that specific soil profile.

75. (A) The water needed to reach field capacity
Soil moisture depletion measures the difference between the current water content and the water content at field capacity. Quantifying this deficit is essential in irrigation management, as it determines the exact volume or depth of water that must be applied to replenish the root zone back to its optimum water storage capacity.

76. (C) $60mm$
The volumetric moisture deficit is calculated as thirty percent minus fifteen percent, which equals fifteen percent. To find the net irrigation depth required to replenish this deficit across a forty-centimeter root zone, multiply fifteen percent by forty centimeters. This multiplication yields six centimeters, which is equivalent to exactly sixty millimeters of net irrigation water.

77. (D) The sum of equivalent water depths across all root-zone horizons
Profile water storage capacity refers to the total depth of water that a complete soil profile can retain within the root zone. It is determined by summing the equivalent water depths calculated individually for each unique soil horizon throughout the root depth, accounting for variations in bulk density and texture across different soil layers.

78. (C) Bulk density
Converting gravimetric water content to volumetric content requires the soil bulk density, as gravimetric measurements only express water relative to dry soil mass. Because equivalent water depth is directly derived from volumetric water content, bulk density serves as the essential conversion factor to translate mass ratios into actual volume-based soil water depths.

79. (B) It can only access a fraction of profile water
Even in deep, fertile soils with high overall profile water storage, shallow-rooted crops are physically restricted from accessing water stored in deeper layers. Because water moves incredibly slowly through unsaturated soil, capillary rise cannot supply moisture fast enough, leaving the crop vulnerable to water stress despite abundant water stored lower in the profile.

80. (D) Measure current θ_g → Convert to θ_v → Calculate equivalent depth → Subtract from equivalent depth at FC
Calculating irrigation requirements begins by measuring the gravimetric water content of the soil. This mass-based value is converted to volumetric water content using bulk density. From this, the current equivalent water depth is calculated and subtracted from the equivalent depth at field capacity, revealing the net depth of irrigation water needed.

81. (A) Potential energy from position above a reference
In soil water dynamics, elevation head represents the gravitational potential energy per unit weight of water at a specific point. This value is determined solely by the vertical position of water relative to an arbitrarily chosen reference datum, serving as a critical component in

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102. (C) It decreases rapidly as soil moisture decreases
In unsaturated soils, hydraulic conductivity is extremely sensitive to soil water content, dropping precipitously as the soil dries. This non-linear decrease occurs because water is removed first from the largest, most conductive pores, forcing the remaining liquid to flow through increasingly narrow, highly tortuous paths near solid mineral particle surfaces.

103. (D) Water must flow through smaller, tortuous pore paths
As soil dries, water is drained from large macropores and becomes confined to smaller micropores. Water movement in these narrow pores faces much higher viscous resistance. Additionally, the remaining water forms thin, highly tortuous films around soil particles, which increases the path length of flow and dramatically reduces the overall unsaturated hydraulic conductivity value.

104. (A) Clay
At high tensions, coarse sand drains almost completely because its large pores cannot retain water against strong suction forces. In contrast, clay soils retain substantial water in their extensive network of micropores. Although clay has a low saturated conductivity, its water-filled micropores allow it to maintain a higher unsaturated hydraulic conductivity at high tension levels.

105. (B) Hydraulic conductivity to specific water capacity
Hydraulic diffusivity is a key parameter in unsaturated flow, defined as the ratio of unsaturated hydraulic conductivity to specific water capacity. Specific water capacity represents the change in water content per unit change in matric potential. Diffusivity simplifies water flow equations by combining these properties, describing how quickly wetness changes propagate through unsaturated soil.

106. (A) The continuity equation (mass conservation)
The Richards equation represents the movement of water in unsaturated soils. It is mathematically derived by combining Darcy's law, which describes fluid flow velocity through porous media, with the continuity equation representing the conservation of mass. This physical principle ensures that any change in water content over time equals the change in water flux over distance.

107. (B) Water movement halts until the fine soil becomes nearly saturated
Water movement stops at the boundary between a fine-textured soil and an underlying coarse-textured layer. Coarse sand has large pores that require higher matric potential to absorb water. Consequently, the overlying fine-textured soil must reach near-saturation conditions to raise the water potential enough for water to enter the large pores of the sand.

108. (B) Large pores empty at low suction, reducing its unsaturated conductivity
Under unsaturated conditions, coarse sand serves as a physical barrier to water flow. The large pores in sand drain rapidly at very low suction, leaving only empty spaces. This rapid drainage drastically decreases the unsaturated hydraulic conductivity of the sandy layer, preventing water from moving downward from the overlying loam until near-saturated conditions occur.

109. (A) Vapor pressure gradient
Subsurface water movement occurs in both liquid and vapor phases. The vapor pressure gradient is the main driving force responsible for the movement of gaseous water through soil pores. Water vapor naturally diffuses from areas of high vapor pressure to areas of lower vapor pressure, which is heavily influenced by temperature and moisture differences.

110. (C) II and III
Gaseous water transport is minimal in saturated soils because air-filled pore space is virtually non-existent. Vapor movement occurs from regions of high vapor pressure to regions of lower vapor pressure. Temperature gradients are a major driver of these vapor pressure differences, as warmer soil zones generate significantly higher vapor pressures than cooler soil zones.

111. (D) Vapor moves from warmer areas to cooler areas
Temperature gradients significantly influence subsurface gaseous water movement. Warming increases the vapor pressure of soil water, creating a pressure gradient. Consequently, water vapor diffuses from warmer soil regions, where vapor pressure is high, toward cooler soil regions, where vapor pressure is lower, facilitating significant

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coefficient. This coefficient adjusts the reference value to reflect the specific developmental stage of the crop.

132. (C) Surface evaporation
During the initial growth stage of a row crop, the seedlings are small, and the crop canopy covers only a minor fraction of the ground. Because the leaf area index is extremely low, plant transpiration is minimal. Consequently, direct physical evaporation from the exposed wet soil surface dominates the total evapotranspiration water loss.

133. (A) Radiation, air temperature, wind speed, and humidity
The Penman-Monteith equation is the internationally accepted standard method for calculating reference evapotranspiration. This physically-based model requires precise meteorological inputs to estimate atmospheric evaporative demand. The essential parameter inputs include net solar radiation, air temperature, wind speed at a standardized height, and relative humidity or vapor pressure deficit.

134. (D) They act as a barrier, reducing vapor transport and heat flux
Organic mulches, such as straw or crop residues, conserve soil moisture by altering the physical boundary layer. They act as a physical barrier that intercepts solar radiation, thereby reducing downward soil heat flux. Additionally, they suppress wind movement at the soil surface, restricting vapor transport and lowering overall evaporation rates.

135. (B) Acting as an impermeable barrier to water vapor loss from the soil
Synthetic plastic mulches, particularly black polyethylene, are widely used in high-value crop production. These materials manage soil water by acting as a highly impermeable physical barrier. They prevent water vapor from escaping from the warm soil surface into the atmosphere, trap evaporated moisture underneath, and return it back to the soil.

136. (C) Leaving crop residues on the surface to reduce runoff
Conservation tillage practices, such as no-till or reduced tillage, enhance soil moisture retention. By leaving crop residues on the soil surface, these practices protect the soil from raindrop impact, preserve aggregate structure, and prevent surface crusting. This increases infiltration, slows down surface water movement, and significantly reduces runoff losses.

137. (D) Cuticle-dissolving
Anti-transpirants are chemical compounds applied to plant foliage to reduce water loss. They are classified into distinct categories based on their mechanism of action, including stomata-closing chemicals, film-forming emulsions, and reflectant materials. Cuticle-dissolving substances are not a recognized category, as damaging the protective waxy cuticle would increase water loss.

138. (A) Stomata-closing
Certain chemical compounds can induce plant guard cells to close, thereby restricting transpiration. Phenylmercuric acetate and abscisic acid are prime examples of stomata-closing anti-transpirants. By artificially initiating stomatal closure during periods of high evaporative demand, these substances reduce water vapor loss through the leaves, conserving plant water reserves.

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139. (B) Creating a physical barrier over stomata that restricts water vapor loss
Film-forming anti-transpirants, such as emulsions of silicone oils, low-viscosity waxes, or plastics, are sprayed directly onto plant foliage. These substances dry to form a thin, transparent physical barrier over the leaf surface. This layer covers the stomata, physically restricting the diffusion of water vapor from the leaf interior into the atmosphere.

140. (A) P-2, Q-4, R-1, S-3
Different classes of anti-transpirants utilize specific mechanisms to reduce crop water loss. Stomata-closing chemicals like phenylmercuric acetate trigger guard cell closure. Film-forming substances such as waxes create physical barriers. Reflectant materials like kaolin clay increase leaf albedo. Growth retardants like cycocel modify canopy architecture to reduce overall transpiration demand.

141. (A) Increasing leaf albedo to reduce leaf temperature and vapor gradient
Reflectant anti-transpirants, such as kaolin clay, are sprayed onto crop canopies to form a

by the letter D denotes deep percolation. This represents the volume of water draining downward past the active crop root zone into deeper aquifers.

122. (A) Precipitation rate exceeds the infiltration capacity
Surface runoff is initiated during wet weather when the rate of water delivery to the soil surface is greater than the rate at which the soil can absorb it. Once the precipitation or irrigation rate exceeds the infiltration capacity of the soil, water begins to pond on the surface and flow downslope as runoff.

123. (B) Deep percolation and seepage
Quantifying individual components of the agricultural water balance is challenging. Deep percolation and lateral subsurface seepage are extremely difficult to measure directly in the field without complex and expensive lysimeter installations. Consequently, these subsurface water fluxes are frequently calculated as the residual term in the water budget equation.

124. (B) Percolation and seepage
Rice paddies are kept under continuously flooded or ponded water conditions throughout much of the cropping season. This continuous ponding maintains a high hydrostatic pressure head over the soil surface. Consequently, downward percolation and lateral seepage through the bunds become the dominant subsurface water loss components in the overall field water budget.

125. (A) The water table is deep enough to avoid waterlogging but shallow enough to reach roots
Capillary rise from a shallow water table can supply significant moisture to growing crops, reducing irrigation needs. However, this process is agronomically beneficial only when the water table is deep enough to prevent root zone waterlogging and oxygen deficiency, while remaining close enough to allow capillary water to reach the root zone.

126. (C) To leach accumulated salts out of the root zone
In arid and semi-arid regions, continuous irrigation and high evaporation rates lead to salt accumulation in the topsoil. To maintain soil productivity, a specific fraction of applied irrigation water must drain downward past the root zone. This deep percolation is essential to leach highly soluble salts away from active plant roots.

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127. (D) Evaporation from the soil and transpiration from the plant canopy
Evapotranspiration represents the total water loss from a vegetated land surface to the atmosphere. This process combines two distinct pathways: physical evaporation, which is the direct vapor loss of water from the soil surface and wet leaves, and biological transpiration, which is the vaporization of water from within plant tissues through stomata.

128. (C) An unrestricted supply of water to the evaporating surfaces
Potential evapotranspiration is an atmospheric demand index representing the maximum possible water loss from a surface. This concept assumes that the soil and vegetation have an unrestricted, continuous supply of water. Under this condition, evapotranspiration rates are limited solely by available solar energy, temperature, wind, and atmospheric humidity levels.

129. (B) A well-watered, actively growing short grass of uniform height
Reference evapotranspiration standardizes water loss calculations by utilizing a specific reference crop. The globally accepted standard reference surface is defined as a hypothetical, well-watered, actively growing short grass of uniform height, completely shading the ground. This baseline allows researchers to compute crop-specific water requirements using dynamic crop coefficients.

130. (D) Both A and R are false.
Actual evapotranspiration is rarely equal to potential evapotranspiration under normal field conditions. As soil dries, water becomes less available to plants, increasing stomatal resistance and restricting transpiration. Therefore, plants transpire at rates far below the maximum potential when soil moisture is limited, making both statements false.

131. (A) The crop coefficient (K_c)
Crop water requirements vary depending on plant species, development stage, and growth characteristics. To calculate actual crop evapotranspiration under standard conditions, the reference evapotranspiration is multiplied by a crop-specific factor known as the crop

92. (C) Pore size distribution
Saturated hydraulic conductivity is primarily determined by the pore size distribution within the soil matrix. According to hydraulic principles, water flows much more rapidly through large macropores than through narrow micropores. Consequently, soils dominated by large pores, such as sand or well-aggregated loam, exhibit significantly higher saturated conductivity than dense, poorly aggregated clay soils.

93. (C) Fourth power (r^4)
Poiseuille's Law describes the laminar flow of fluids through cylindrical tubes, stating that flow rate is proportional to the fourth power of the channel radius. In soil physics, this relationship highlights the disproportionate impact of pore size on hydraulic conductivity, demonstrating why a small increase in pore radius leads to a massive increase in water flow.

94. (C) Atmospheric CO_2 levels
Saturated hydraulic conductivity is governed by physical parameters of the soil-water system, including soil texture, structure, aggregate stability, total porosity, and water viscosity. However, ambient atmospheric carbon dioxide levels have no direct, significant physical influence on the rate at which liquid water moves through a fully saturated soil matrix under typical agricultural field conditions.

95. (B) The entry of water into the soil surface
Infiltration is defined as the physical process by which water enters the soil profile through its upper surface boundary. This crucial hydrologic mechanism governs how much rainfall or irrigation water successfully penetrates into the soil to become available for crop root uptake, rather than being lost to lateral agricultural surface runoff.

96. (D) Starts high and decreases to a steady rate
During steady rainfall, the soil infiltration rate starts high and declines gradually over time. Initially, dry soil experiences strong matric suction gradients that rapidly pull water inward. As the surface layer saturates, this suction gradient diminishes, and the physical breakdown of surface aggregates may block pores, causing infiltration to stabilize at a lower, steady rate.

97. (A) Saturated conductivity of the limiting horizon
After prolonged wetting, the infiltration rate stabilizes at a constant value, known as the steady-state infiltration capacity. At this stage, the matric suction gradient approaches zero, and flow is driven solely by gravity. Consequently, this steady rate is approximately equal to the saturated hydraulic conductivity of the most restrictive, or limiting, soil horizon layer.

98. (C) Downward water movement through the soil profile
Infiltration and percolation represent distinct phases of water movement. While infiltration refers specifically to the initial entry of water through the soil surface boundary, percolation describes the subsequent, deep downward movement of that infiltrated water through the internal soil profile and horizons, driven by hydraulic and gravitational gradients.

99. (A) Horton's equation
Horton's equation is a classical empirical model used to describe the decline of infiltration capacity over time during a rain event. It mathematically represents how the infiltration rate starts at an initial maximum value and decays exponentially toward a constant, minimum steady-state rate as the soil profile becomes increasingly saturated with water.

100. (A) P-3, Q-4, R-2, S-1
Different water transport mechanisms in soils are driven by specific gradients. Saturated flow is motivated by positive hydrostatic pressure and gravity. Unsaturated flow is driven by matric suction and gravity gradients. Vapor flow moves along vapor pressure gradients, and osmotic flow is driven by solute concentration gradients across selective semi-permeable membrane barriers inside the plant system.

101. (B) Matric suction head
In unsaturated soil profiles, water movement is dictated by total hydraulic head gradients. Because the soil is not completely saturated, hydrostatic pressure head is absent and is replaced by the negative matric suction head. Therefore, the active driving forces governing unsaturated water movement include both the elevation head and this matric suction head.

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white powdery coating. This coating increases the leaf albedo, allowing the foliage to reflect a higher proportion of incoming solar radiation. Consequently, leaf temperature decreases, reducing the vapor pressure gradient between the leaf interior and the atmosphere.

142. (C) Can restrict CO_2 diffusion, thereby reducing photosynthesis
Although film-forming anti-transpirants successfully reduce transpiration by blocking stomatal openings, they possess a major agronomic disadvantage. The artificial physical barrier is not selectively permeable to water vapor alone. It also restricts the inward diffusion of carbon dioxide into the leaf, which severely limits photosynthesis and reduces overall crop yield.

143. (D) Decreasing wind velocity to increase boundary layer thickness and reduce vapor loss
Windbreaks or shelterbelts are barriers of trees and shrubs designed to protect crops. They conserve water within the crop canopy primarily by reducing wind velocity across the field. Lower wind speeds increase the thickness of the boundary layer of calm air surrounding the leaves, which significantly reduces the rate of water vapor transport.

144. (C) The height of the windbreak (H), protecting up to 15-20 H leeward
The microclimatic protection provided by a windbreak is directly related to its physical dimensions. The effective zone of reduced wind speed on the leeward side is proportional to the height of the windbreak. Significant reductions in wind velocity and subsequent evapotranspiration are typically observed up to fifteen to twenty times the barrier height leeward.

145. (B) A decrease in total porosity and an increase in mechanical impedance
Soil compaction occurs when external forces compress the soil, leading to an increase in bulk density. This structural degradation results in a significant decrease in total porosity, particularly reducing the volume of large macropores. Consequently, soil particles are packed closer together, which dramatically increases the mechanical impedance encountered by growing roots.

146. (C) $2.0 - 3.0 MPa$
Mechanical impedance refers to the physical resistance that soil offers to root penetration. As soil strength increases due to compaction or drying, roots must exert greater force to expand. Standard penetrometer resistance values between two and three megapascals represent a critical threshold where root elongation is severely restricted or completely halted in most crops.

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147. (B) 10%
Root respiration requires a continuous supply of oxygen from the soil atmosphere. Gas exchange occurs primarily through air-filled pores. When water content is high and the volumetric air-filled porosity drops below approximately ten percent, gas diffusion becomes extremely restricted, resulting in oxygen deficiencies that severely limit root growth in most plants.

148. (C) It increases conductivity because water conducts heat better than air
Soil thermal conductivity is heavily influenced by moisture content. Liquid water is a much better conductor of heat than static air, which acts as an insulator. When water displaces air in soil pores, it creates thermal bridges between solid mineral particles, dramatically increasing the overall rate of heat transfer through the soil profile.

149. (A) Water has a high specific heat, requiring more energy to raise its temperature
Wet soils exhibit a slow thermal response during spring warming compared to dry soils. This phenomenon is primarily due to the high specific heat capacity of liquid water, which is about five times greater than that of dry soil minerals. Consequently, wet soils require significantly more thermal energy to increase their temperature by one degree.

150. (B) I, III, IV
Soil erodibility represents the vulnerability of soil to detachment and transport by erosive forces. Silt and very fine sand fractions are highly susceptible to water erosion because they lack cohesion and are easily transported. Conversely, high soil organic matter content promotes aggregate stability, thereby reducing soil erodibility and enhancing resistance to erosion.

151. (B) Soil erodibility factor
The Universal Soil Loss Equation is a widely accepted empirical model used to estimate average annual soil loss from water erosion. Within this formula, the K-factor specifically represents the soil erodibility factor. This quantitative index reflects the inherent susceptibility of a particular soil type to particle detachment and transport by water.

152. (C) Silt loam
Inherent physical properties dictate soil erodibility. Silt loam soils typically exhibit the highest K-factor values in the Universal Soil Loss Equation. Silt particles are small enough to be easily transported by running water, yet they lack the cohesive properties of clay minerals, making them exceptionally vulnerable to detachment and erosion.

153. (D) Clay soils possess cohesive forces that promote stable aggregation
Clayey soils are less erodible than silty soils, despite their smaller individual particle size. This resistance is due to the chemical and physical properties of clay minerals, which exhibit strong cohesive forces. These forces bind individual clay particles into larger, stable structural aggregates that resist detachment by raindrop impact and surface runoff.

154. (A) Influencing infiltration rate, which determines surface runoff volume
Soil profile permeability plays a critical role in determining overall erodibility. High permeability allows water to infiltrate rapidly through the soil profile, reducing ponding. This high infiltration rate directly decreases the volume and velocity of surface runoff generated during rainfall events, thereby minimizing the hydraulic energy available for soil particle transport.

155. (B) Wischmeier's erodibility nomograph
Estimating the K-factor in the Universal Soil Loss Equation requires integrating multiple soil physical properties. Wischmeier's erodibility nomograph is the standard tool used for this purpose. It utilizes key soil parameters, including the percentage of silt and very fine sand, organic matter content, soil structure code, and profile permeability class.

156. (B) III → II → I
Selecting appropriate soil conservation practices depends heavily on the slope gradient of the terrain. For relatively flat or gentle slopes, contour farming is preferred. As slopes become steeper, strip cropping is utilized to slow down runoff. On very steep agricultural terrains, highly intensive bench terracing is required to physically modify the slope.

157. (A) Providing vegetative cover to intercept rain and slow runoff
Agronomic measures represent biological approaches to erosion control. These methods focus on utilizing vegetative cover and crop management practices to protect the soil. Plants and crop residues physically intercept falling raindrops, dissipating their kinetic energy before impact, while also acting as surface obstructions that slow the velocity of overland water flow.

158. (C) Creating small surface ridges that catch and retain runoff water
Contour farming involves performing all agricultural operations, such as plowing, planting, and cultivating, across the slope rather than up and down. This practice creates small, horizontal ridges and furrows along the contour lines. These physical ridges act as miniature dams that temporarily detain runoff water, promoting increased infiltration and reducing erosion.

159. (D) Alternating bands of close-growing crops and row crops
Strip cropping is an effective agronomic practice for controlling water erosion on sloping lands. It involves growing alternating bands of row crops, which leave much of the soil exposed, and close-growing, dense cover crops. The dense bands slow the velocity of surface runoff and filter out suspended sediment eroded from the row crop strips.

160. (B) Detachment → Transport → Deposition
Water erosion is a progressive physical process consisting of three sequential phases. The process begins with detachment, where raindrop impact or flowing water separates individual soil particles from the soil mass. These detached particles are then carried away during the transport phase by running water, and finally settle out during the deposition phase.

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161. (B) Filtering suspended sediment and slowing runoff, forming terraces over time
Vegetative barriers, such as contour hedges of dense vetiver grass, are highly effective biological conservation tools. When surface runoff hits these barriers, its velocity is drastically reduced, causing suspended soil particles to settle out. Over time, this continuous deposition of sediment on the upslope side of the hedges leads to natural terrace formation.

162. (D) Agronomic measures alone are insufficient on steep slopes with high rainfall
While biological conservation methods are cost-effective, they have physical limits. Engineering or mechanical erosion control measures become necessary when agricultural fields are located on steep slopes subject to high-intensity rainfall. In these high-risk scenarios, agronomic measures cannot handle the volume of runoff, requiring structural intervention to safely manage excess water.

163. (A) Low rainfall ($< 600mm$) and permeable soils to conserve moisture
Contour bunding involves constructing small earthen embankments along contour lines. This specific mechanical measure is most suited for arid and semi-arid areas characterized by low annual rainfall and highly permeable soils. The primary goal is to impound surface runoff behind the bunds, allowing it to fully infiltrate and conserve valuable moisture.

164. (C) Graded bunding
In high-rainfall areas where soils are easily saturated, impounding water along the contour can cause waterlogging or bund failure. Under these conditions, graded bunding is preferred over contour bunding. Graded bunds are constructed with a slight longitudinal slope, allowing them to safely collect and divert excess runoff into a grassed waterway.

165. (C) 16% to 33%
Bench terracing is a highly intensive mechanical erosion control measure used to cultivate steep slopes. This practice physically reshapes the hillside into a series of flat, step-like platforms. Bench terraces are generally recommended and economically justified for slopes ranging between sixteen and thirty-three percent, where simpler agronomic measures fail to control erosion.

166. (D) Manage drainage in heavy clay soils while conserving moisture
The Broad Bed and Furrow system is a specialized land-shaping technology designed primarily for heavy clay soils, such as Vertisols. These soils are prone to severe waterlogging during wet periods. The system manages this by utilizing wide, raised beds for crop growth while the intervening furrows safely drain excess water, conserving moisture simultaneously.

167. (B) It has a slight longitudinal slope to guide excess water to a waterway
Graded terraces are physical channel-and-ridge structures built across agricultural slopes. Unlike level terraces, they are constructed with a precise, slight longitudinal slope. This grade ensures that excess surface runoff is slowly guided along the channel toward a stable, grassed waterway, preventing high-velocity flow and subsequent rill or gully erosion.

168. (C) Safely transport concentrated runoff down the slope without gully erosion
Grassed waterways are critical components of agricultural drainage and erosion control designs. These wide, shallow, vegetated channels are specifically engineered to collect runoff from terraces or bunds. The dense grass lining stabilizes the soil channel, reducing water flow velocity and allowing the safe transport of concentrated runoff downslope without initiating gully erosion.

NODIA

169. (D) To reduce the gully channel gradient and dissipate flowing water energy
Gully erosion is controlled by reducing the erosive power of concentrated runoff. Drop structures and temporary check dams are constructed across active gullies to achieve this. These barriers lower the effective channel gradient, creating a series of steps that dissipate the kinetic energy of the flowing water and encourage sediment deposition behind the structures.

170. (A) Both A and R are true and R is the correct explanation of A.
Applying organic mulch to the soil surface is an effective way to minimize water erosion. The physical layer of mulch acts as a protective shield that directly intercepts falling raindrops. By absorbing and dissipating the kinetic energy of raindrop impact, the mulch prevents soil

(C) It inhibits the function of root aquaporins.
(D) It decreases the vapor pressure deficit, thereby reducing the transpiration rate.

2005
35. Identify the correct statement regarding active and passive water absorption by roots.
(A) Passive absorption is primarily driven by transpirational pull from the shoot.
(B) Active absorption accounts for more than 90% of a plant's total water uptake during the day.
(C) Active absorption occurs independently of root respiration.
(D) Passive absorption requires the direct expenditure of ATP by root hair cells.

2007
36. Root pressure is an example of which type of water uptake mechanism?
(A) Tension-driven passive absorption
(B) Capillary action in the phloem
(C) Osmotic active absorption
(D) Imbibition by the root pericycle

2006
37. Which metabolic inhibitor would most directly and severely reduce active water absorption in roots?
(A) A cellular respiration inhibitor like cyanide
(B) An inhibitor of photosynthesis (e.g., DCMU)
(C) An inhibitor of gibberellin biosynthesis
(D) An inhibitor of cuticle synthesis

2015
38. Select the correct sequence representing the primary pathways of radial water transport in roots from the epidermis to the endodermis:
(A) Symplastic, Apoplastic, Vascular
(B) Transmembrane, Apoplastic, Phloemic
(C) Apoplastic, Transmembrane, Xylemic
(D) Apoplastic, Symplastic, Transmembrane

2024
39. The apoplastic pathway of water movement in roots is effectively blocked at the endodermis by the:
(A) Plasmodesmata
(B) Casparian strip
(C) Tonoplast
(D) Primary cell wall of the pericycle

2019
40. The Casparian strip is chemically characterized by the heavy deposition of which hydrophobic biopolymer?
(A) Cellulose
(B) Pectin
(C) Suberin
(D) Chitin

2007
41. Why is the blockage of the apoplastic pathway at the endodermis physiologically crucial for the plant?
(A) It prevents the leakage of water out of the vascular cylinder back into the cortex.
(B) It forces water and solutes to cross a selective plasma membrane, allowing regulation of ion uptake.
(C) It generates the transpirational pull necessary for ascent of sap.
(D) Both (A) and (B) are correct.

2013
42. In the symplastic pathway, water and solutes move between adjacent plant cells primarily through:
(A) Plasmodesmata
(B) Aquaporins
(C) Intercellular air spaces
(D) The middle lamella

2024
43. Which radial transport pathway involves water crossing the plasma membrane of each cell in its path twice (entry and exit)?
(A) Apoplastic pathway
(B) Transmembrane route
(C) Symplastic pathway
(D) Casparian pathway

2021
44. Based on the cohesion-tension theory, the tensile strength of water in the xylem is maintained by:
(A) Covalent bonds between oxygen and hydrogen atoms of adjacent water molecules.
(B) Extensive hydrogen bonding among water molecules (cohesion).
(C) The pumping action of specialized xylem parenchyma cells.
(D) The positive root pressure pushing water upward.

2017
45. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cavitation in xylem vessels leads to the formation of air embolisms that block water transport.
Reason (R): High negative pressure (tension) in

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high suction, while low air-filled porosity induces root hypoxia, reducing nutrient and water absorption.

181. (A) It decreases uptake due to higher water viscosity and lower membrane permeability
Low soil temperatures restrict the ability of plant roots to absorb water. Cold conditions increase the physical viscosity of liquid water, making it harder to move. Additionally, low temperatures reduce the physiological permeability of root cell membranes by altering lipid fluidity, leading to a marked decrease in overall water uptake by the plant.

182. (D) Thermal conductivity divided by volumetric heat capacity
Soil thermal diffusivity is a physical property that dictates the rate at which temperature changes propagate through the soil profile. Mathematically, it is defined as the soil thermal conductivity divided by the volumetric heat capacity. This ratio reflects how quickly a soil warms or cools in response to boundary temperature fluctuations.

183. (C) Several hours after surface maximum due to thermal lag
Soil conducts heat downward from the surface slowly. This slow transfer creates a distinct thermal lag in deeper soil layers. While the maximum soil surface temperature typically occurs shortly after solar noon, the maximum temperature at a depth of fifteen centimeters is delayed by several hours due to this progressive heat conduction process.

184. (C) The depth where the temperature wave amplitude is reduced to 37% of its surface value
Soil temperature fluctuations decrease exponentially with depth. The damping depth is a physical parameter defined as the specific depth at which the amplitude of the diurnal or annual temperature wave is reduced to approximately thirty-seven percent of its surface amplitude. Below this depth, the soil temperature remains relatively constant.

185. (D) $1.6 g/cm^3$
Soil bulk density is a key indicator of compaction. In loamy soils, a bulk density threshold of approximately one point six grams per cubic centimeter typically restricts root penetration. At this high density, the soil pores are compressed, and the mechanical resistance of the matrix exceeds the maximum pressure that plant roots can exert.

186. (A) Macropores (aeration pores)
External compaction forces alter soil structure by compressing the pore network. This compaction primarily reduces the volume of large macropores, which are crucial for soil aeration and rapid water drainage. In contrast, the volume of smaller micropores remains relatively unaffected or may even increase slightly as larger pores are squeezed shut.

187. (B) Restricting root penetration and causing temporary waterlogging
Hardpan formations are highly compacted, dense subsoil layers that present severe physical limitations. They adversely affect crop development by physically restricting downward root penetration, forcing roots to grow laterally. Additionally, these dense layers have very low hydraulic conductivity, which blocks drainage and causes temporary waterlogging in the overlying root zone.

NODIA

188. (B) Air-filled porosity
Gas transport through the soil matrix occurs primarily via diffusion. According to Penman's empirical relation, the ratio of the soil gas diffusion coefficient to the free-air diffusion coefficient is directly related to the air-filled porosity of the soil. This linear relationship highlights that gas diffusion is governed by the volume of open, air-filled pores.

189. (A) Promoting aggregation, increasing porosity, and lowering bulk density
Organic matter additions significantly improve soil physical quality. Decomposing organic materials release binding agents that promote the formation of stable soil aggregates. This aggregation increases total porosity, especially the proportion of macropores, while simultaneously lowering the bulk density. These structural improvements facilitate optimal root growth, water infiltration, and soil aeration.

190. (B) III, IV
Soil physical processes are highly interdependent. Statement three is incorrect because soil aeration is directly dependent on water content, as water displays air in pores. Statement four is incorrect because mechanical impedance actually increases

CHAPTER 11
Plant Water Relationship

2022

1. Which of the following best defines the specific heat capacity of water in the context of plant thermal regulation?
(A) The amount of energy required to convert one gram of liquid water to vapor at constant temperature.
(B) The heat energy required to raise the temperature of one gram of water by one degree Celsius.
(C) The energy needed to break the hydrogen bonds between adjacent water molecules during transpiration.
(D) The measure of water's ability to dissolve polar solutes in the cell cytoplasm.

2017

2. The high latent heat of vaporization of water provides which primary physiological advantage to plants?
(A) It facilitates the rapid expansion of vacuoles during cell growth.
(B) It enhances the solubility of mineral nutrients in xylem sap.
(C) It maintains the structural integrity of the root endodermis.
(D) It allows for cooling of leaves during active transpiration.

2025

3. Identify the INCORRECT statement regarding the physico-chemical properties of water.
(A) The cohesive forces between water molecules are primarily driven by covalent bonding.
(B) Water is a polar molecule with a dipole moment due to unequal electron sharing.
(C) The maximum density of pure water occurs at approximately 4 degrees Celsius.
(D) Water possesses a high dielectric constant, making it an excellent solvent for ionic compounds.

2002

4. In plant physiology, the property of water that describes its attraction to solid surfaces, such as cell walls and soil particles, is termed:
(A) Cohesion
(B) Surface tension
(C) Adhesion
(D) Capillarity

2015

5. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Water serves as an excellent temperature buffer within plant tissues.
Reason (R): Water possesses a very low specific heat capacity, allowing rapid thermal equilibration with the environment.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

6. If a plant cell is placed in a strongly hypertonic solution, the resulting physiological process will most likely be:
(A) Rapid increase in turgor pressure leading to cytolysis.
(B) Enhanced imbibition of water by the cellulosic cell wall.
(C) Active transport of water into the cell against the concentration gradient.
(D) Plasmolysis due to the exosmosis of water from the vacuole.

2011

7. Which of the following mechanisms is primarily responsible for the initial swelling of dry seeds when placed in water?
(A) Osmosis
(B) Imbibition
(C) Active absorption
(D) Transmembrane diffusion

2009

8. Consider the following statements regarding foundational transport mechanisms in plants:
I. Diffusion is a passive process driven by a concentration gradient.

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absorption terrace is specifically constructed with a perfectly level channel and ridge. This design is engineered to retain all incident rainfall within the terrace channel, preventing runoff and maximizing water infiltration into the root zone.

202. (A) The percentage of microporosity
Soil water states reflect the pore size distribution. At saturation, all soil pores are filled with water. At field capacity, water has drained from the large macropores under gravity, leaving water only in the smaller micropores. Therefore, the ratio of water content at field capacity to saturation provides an estimate of microporosity.

203. (B) Its slow response time to moisture changes
Gypsum blocks are commonly used to monitor soil moisture for irrigation scheduling. However, their usefulness is limited by their slow response time to rapid changes in soil moisture. Because water must diffuse into or out of the block to reach equilibrium with the surrounding soil, there is a significant lag in readings.

204. (B) II, III
Understanding soil water potential components is fundamental to soil physics. Statement two is incorrect because gravitational potential is negative below the selected reference datum. Statement three is incorrect because osmotic potential does not drive the mass flow of liquid water in saturated soils; instead, mass flow is driven by hydrostatic and gravitational potential gradients.

205. (A) The clay layer permeability once the wetting front reaches it
Textural boundaries within a soil profile strongly affect water movement. In a sand-over-clay profile, water initially infiltrates rapidly through the highly permeable sand. However, once the wetting front reaches the underlying clay layer, the infiltration rate is governed by the lower permeability of the clay, which acts as the hydraulic bottleneck.

206. (C) Conductivity varying depending on flow direction (e.g., vertical vs. horizontal)
Soils are often structurally complex and non-uniform. Anisotropy in soil hydraulic conductivity refers to the phenomenon where hydraulic conductivity values vary depending on the direction of water flow through the soil matrix. In many structured soils, horizontal hydraulic conductivity is significantly higher than vertical hydraulic conductivity due to layered deposition or structural cracking.

207. (A) I, V
Evapotranspiration dynamics depend on atmospheric and soil conditions. Statement one is incorrect because actual evapotranspiration can never exceed potential evapotranspiration, which represents the upper physical limit. Statement five is incorrect because wind generally increases evapotranspiration by removing the humid boundary layer of air surrounding the plant leaves, rather than suppressing it.

208. (C) Immediately above the water table where soil is nearly saturated under negative pressure
The capillary fringe is a distinct hydrological zone in the soil profile. It is located immediately above the free water table. In this zone, the soil pores are nearly or completely filled with water pulled upward by capillary forces. However, unlike the groundwater below, the water in this fringe is under negative pressure.

209. (B) Salinity, which relates to osmotic potential
Measuring the electrical conductivity of a soil saturated paste extract is a standard diagnostic procedure. This measurement is conducted primarily to assess soil salinity. High electrical conductivity indicates a high concentration of dissolved salts, which lowers the osmotic potential of the soil solution and makes it harder for plants to absorb water.

210. (A) II → I → IV → III
Soil moisture states represent different energy levels of water. At saturation, water is held at the highest energy state and is highly mobile. At field capacity, water is held moderately. At the permanent wilting point, water is held tightly. At the hygroscopic coefficient, water is held at the lowest energy state, bound extremely tightly.

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aggregate detachment and subsequent runoff transport, validating both statements.

171. (B) Long-term average annual sheet and rill erosion from a field slope
The Universal Soil Loss Equation is an empirical model developed to estimate agricultural soil loss. It is designed specifically to predict long-term, average annual soil losses resulting from sheet and rill erosion on a given field slope. It does not predict localized gully erosion, wind erosion, or the exact sediment delivery to downstream aquatic systems.

172. (B) Conservation tillage
Tillage systems are classified based on the amount of plant residue left on the soil surface after planting. Systems that maintain at least thirty percent crop residue cover are categorized as conservation tillage. This residue cover protects the soil from raindrop impact, reduces wind and water erosion, and enhances long-term soil water conservation.

173. (A) Cover-management factor
The Revised Universal Soil Loss Equation incorporates updated experimental data to predict water erosion. In this empirical model, the C-factor represents the cover-management factor. This factor quantifies the combined effect of cropping systems, tillage methods, crop residue management, and soil surface cover on reducing soil loss compared to bare soil.

174. (C) Inherent soil texture and profile depth
Soil erosion is influenced by both manageable and unchangeable factors. While crop rotation, tillage direction, and terracing can be altered through farm management, inherent soil texture and total profile depth are intrinsic physical properties. These permanent soil characteristics dictate erodibility and water storage capacity, and cannot be significantly altered by management practices.

175. (D) It resists water slaking and dispersion, reducing detachment
A highly stable soil aggregate structure is essential for minimizing water erosion. Aggregates that possess high structural stability resist slaking and dispersion when wetted by rainfall. This stability prevents the breakdown of soil crumbs into easily transportable individual clay and silt particles, thereby reducing detachment and preventing surface crust formation.

176. (C) Sodium (Na^{+})
Soil chemical properties strongly influence physical behavior. When monovalent sodium ions dominate the cation exchange complex, they cause clay particles to swell and disperse upon wetting. This dispersion destroys soil aggregate structure, blocks pore spaces, and dramatically increases soil erodibility, making sodic soils highly susceptible to detachment and water transport.

177. (B) Accumulation of toxic gases like ethylene and hydrogen sulfide
Poor soil aeration occurs when water fills the pore space, limiting gas exchange with the atmosphere. This anaerobic condition restricts oxygen supply, causing microbial processes to shift to anaerobic pathways. Consequently, toxic gases like ethylene and hydrogen sulfide accumulate in the root zone, severely inhibiting root respiration, cell division, and nutrient uptake.

178. (A) $20 \times 10^{-8} gcm^{-2}\text{min}^{-1}$
The oxygen diffusion rate is a critical physical parameter that measures the rate at which oxygen is supplied to active root surfaces. For most agricultural crops, root development and metabolic activity are severely restricted when the oxygen diffusion rate falls below a critical threshold of approximately twenty times ten to the minus eight.

NODIA

179. (A) The minimum temperature below which germination ceases
Temperature regulates the biochemical reactions within seeds during germination. The concept of base temperature refers to the specific minimum temperature threshold below which metabolic activity halts and germination ceases. Each crop species has a distinct base temperature, and planting when soil temperatures are below this value leads to seed rot.

180. (A) P-3, Q-4, R-1, S-2
Physical soil conditions directly control plant growth and development. High bulk density increases mechanical impedance to root elongation. Low soil temperature delays seed germination and slows metabolic rates. Low matric potential restricts water uptake due to

II. Osmosis specifically refers to the movement of solutes across a semi-permeable membrane.
III. Imbibition requires an affinity between the imbibant and the liquid.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II
(D) I

2002
9. Which of the following scenarios best illustrates the concept of diffusion in a plant system?
(A) The movement of water from the soil into root hairs through aquaporins.
(B) The active loading of sucrose into the phloem sieve elements.
(C) The swelling of a dry wooden door during high humidity.
(D) The loss of water vapor from leaves to the atmosphere.

2005
10. The term "incipient plasmolysis" refers to the specific cellular state where:
(A) The turgor pressure is zero, and the protoplast begins to recede from the cell wall.
(B) The protoplast has completely detached from the cell wall and rounded up in the center of the cell.
(C) The cell has reached its maximum volume and wall pressure equals turgor pressure.
(D) The Diffusion Pressure Deficit (DPD) equals the osmotic pressure plus turgor pressure.

2004
11. Which of the following relationships correctly defines Diffusion Pressure Deficit (DPD)?
(A) DPD = Osmotic Pressure (OP) - Turgor Pressure (TP)
(B) DPD = Osmotic Pressure (OP) / Turgor Pressure (TP)
(C) DPD = Turgor Pressure (TP) - Osmotic Pressure (OP)
(D) DPD = Osmotic Pressure (OP) + Turgor Pressure (TP)

2006
12. A decrease in the turgor pressure of a guard cell directly causes:
(A) An increase in the size of the stomatal aperture.
(B) Flaccidity of the guard cell and stomatal closure.
(C) Active uptake of potassium ions from subsidiary cells.
(D) Degradation of abscisic acid (ABA) in the cytoplasm.

2005
13. Which concept is most relevant for understanding why water enters a flaccid cell placed in pure water?
(A) The cell has lower water potential than the surrounding pure water.
(B) The pure water has a higher solute concentration than the cell sap.
(C) The cell wall exerts a negative pressure potential pulling water inward.
(D) The matric potential of the vacuole is higher than that of the external solution.

2012
14. What is the fundamental difference between turgor pressure and wall pressure in a fully turgid plant cell?
(A) Turgor pressure is exerted by the cell wall inward, while wall pressure is exerted by the protoplast outward.
(B) Turgor pressure is driven by active transport, whereas wall pressure is driven by osmosis.
(C) They are equal in magnitude but opposite in direction.
(D) Turgor pressure is independent of solute concentration, unlike wall pressure.

2002
15. Match the cellular water relation terms in List I with their appropriate descriptions in List II.
List I: Cellular water relation terms
P. Osmosis
Q. Plasmolysis
R. Turgor pressure
S. Imbibition
List II: Descriptions
1. Outward hydrostatic pressure exerted against the cell wall
2. Adsorption of water by hydrophilic colloids
3. Movement of water across a selectively permeable membrane
4. Shrinkage of protoplast due to exosmosis
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-3, S-1

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as soil dries, because drying increases soil strength and matric suction, making it harder for roots to penetrate.

191. (D) Increasing clay and organic matter content
Water retention in soils is governed by surface area and pore size distribution. Increasing the clay and organic matter content enhances water retention. Clay particles and organic matter have very high specific surface areas and possess abundant functional groups that hold water molecules tightly via adsorption and capillary forces.

192. (C) Heavy clay
Soil texture determines the total pore volume and pore size distribution. Heavy clay soils possess the highest total porosity and therefore hold the maximum volume of water at saturation. However, they do not provide the most plant-available water because they hold much of this water very tightly within tiny micropores at high suction.

193. (B) Rapid bypass flow of water into deep soils
Fine-textured soils containing expansive clay minerals shrink and crack upon drying. These large, open structural cracks create continuous vertical pathways. During subsequent rainfall or irrigation events, water can flow directly down these cracks, bypassing the main soil matrix. This process contributes to rapid bypass flow or preferential flow into deeper profile layers.

194. (D) High silt content and a shallow water table supplying capillary water
Frost heaving is a physical process that occurs when freezing soil water expands and forms ice lenses, pushing the soil upward. This destructive phenomenon occurs primarily in soils with high silt content and a shallow water table. Silt pores are optimal for continuous capillary rise, which constantly supplies water to the growing ice lenses.

195. (A) Volumetric heat capacity
Thermal properties govern the temperature dynamics of the soil profile. The specific property that dictates the quantity of heat energy required to raise the temperature of a unit volume of soil by one degree Celsius is the volumetric heat capacity. This parameter is highly dependent on the relative proportions of soil solids, water, and air.

196. (C) Are cheaper and protect the soil surface from rainsplash
Agronomic measures represent the first line of defense in soil conservation planning. These biological practices are highly cost-effective and easy to implement. By maintaining crop cover, they protect the soil surface from the physical impact of falling raindrops, which prevents soil detachment, controls surface crusting, and minimizes subsequent erosion.

197. (A) Wet sieving analysis
Aggregate stability is a key indicator of a soil's resistance to water erosion. In the laboratory, the structural stability of soil aggregates against water slaking and mechanical forces is standardly tested using wet sieving analysis. This method measures the percentage of water-stable aggregates that resist breakdown when submerged and oscillated in water.

198. (D) Deep inversion plowing annually
Conservation agriculture is a sustainable farming approach based on three core physical and biological principles. These are maintaining a permanent organic soil cover, practicing diverse crop rotations, and minimizing mechanical soil disturbance. Annual deep inversion plowing is not a principle of conservation agriculture; instead, it is highly destructive to soil structure.

199. (B) Providing vegetative cover during otherwise fallow periods
Cover crops are planted primarily to protect and improve the soil. They reduce water and wind erosion by providing continuous vegetative cover during fallow periods when the main cash crop is not growing. This cover intercepts raindrops, slows surface runoff, stabilizes the soil with root systems, and adds organic matter.

NODIA

200. (D) I, II, and III
Structural and mechanical measures are essential components of integrated watershed management. Check dams are built across gully beds to reduce water velocity and trap sediment. Contour bunds are earthen ridges constructed across slopes to detain runoff. Terraces physically shorten the effective slope length, reducing the volume and erosive capacity of runoff.

201. (D) Level absorption terrace
In arid and semi-arid regions with limited rainfall, conserving every drop of water is critical. A level

(B) Pressure potential — Ψ_p
(C) Matric potential — Ψ_m
(D) Gravity potential — Ψ_w

2017

26. Which of the following is an exception to the rule that pressure potential (Ψ_p) in living plant cells is typically positive?
(A) Plasmolyzed mesophyll cells
(B) Fully turgid guard cells
(C) Expanding hypocotyl cells
(D) Root cortical cells during active absorption

2003

27. Aquaporins facilitate water transport across biological membranes primarily by:
(A) Utilizing ATP to actively pump water molecules against their gradient.
(B) Providing a low-resistance protein channel for passive diffusion of water.
(C) Creating a non-selective pore that allows both ions and water to pass freely.
(D) Binding water molecules and undergoing a conformational change to transport them.

2011

28. Consider the following statements concerning aquaporins:
I. They are integral membrane proteins belonging to the Major Intrinsic Protein (MIP) family.
II. Their activity can be regulated by cytosolic pH and calcium levels.
III. They are exclusively located in the plasma membrane (PIPs) and absent from the tonoplast.
IV. Phosphorylation plays a key role in the gating of some aquaporins.
V. They prevent the passage of protons to maintain membrane potential.
Which of the above statements is/are correct?
(A) I, II, III and V
(B) I, II, IV and V
(C) I, III, IV and V
(D) II, III and IV

2013

29. The gating of aquaporins in response to the drought stress frequently involves:
(A) Dephosphorylation and cytosolic acidification.
(B) Depletion of membrane lipids.
(C) Rapid insertion of aquaporins from the cell wall into the plasma membrane.
(D) Active ATP-dependent closure of the channel pore.

2022

30. Which cellular membrane contains Tonoplast Intrinsic Proteins (TIPs), a specific subfamily of aquaporins?
(A) Plasma membrane
(B) Inner mitochondrial membrane
(C) Vacuolar membrane
(D) Chloroplast envelope

2017

31. Under severe flooding (hypoxia), root water uptake often decreases drastically. The primary cause for this at the transcellular level is:
(A) Immediate degradation of the Casparian strip.`
(B) Reversal of the water potential gradient between soil and root.`
(C) Excessive accumulation of root pressure.`
(D) Closure of aquaporins due to cytosolic acidification.`

2003

32. In the Soil-Plant-Atmosphere Continuum (SPAC), the primary driving force for the upward movement of water is:
(A) The positive hydrostatic root pressure generated by active ion transport.
(B) The active transport of water in the stem xylem.
(C) The water potential gradient between leaves and the atmosphere.
(D) The high osmotic pressure of the soil solution.

2010

33. Which component of the SPAC provides the greatest resistance to water flow under well-watered soil conditions?
(A) The radial pathway of water transport across the root cortex.
(B) Stomatal resistance at the leaf-atmosphere interface.
(C) The axial resistance within the conducting stem xylem.
(D) The hydraulic resistance within the leaf petiole.

2004

34. What effect does high atmospheric relative humidity have on the SPAC?
(A) It increases the steepness of the water potential gradient, enhancing transpiration.
(B) It causes the leaf water potential to become significantly more negative.

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2009

16. In thermodynamic terms, the water potential of pure water at standard temperature and atmospheric pressure is defined as:
(A) -1.0 MPa
(B) 0 MPa
(C) +100 kPa
(D) +1.0 MPa

2014

17. The standard SI unit for measuring plant water potential is the:
(A) Joule per mole
(B) Megapascal
(C) Milliosmole
(D) Bar

2023

18. Consider the following statements regarding plant water potential:
I. Water potential dictates the direction of water movement from lower to higher potential.
II. Solute potential is always a negative value in plant cells.
III. Pressure potential can be negative in xylem vessels during active transpiration.
IV. Matric potential is typically a large positive value in saturated soils.
Which of the above statements is/are INCORRECT?
(A) I, II and III
(B) I and IV
(C) II, III and IV
(D) II and III

2002

19. If cell A has a water potential of -0.8 MPa and cell B has a water potential of -1.2 MPa, what will be the net direction of water movement?
(A) From cell A to cell B
(B) From cell B to cell A
(C) There will be no net movement as both are negative
(D) Water will move out of both cells into the apoplast

2013

20. The addition of solute molecules to pure water alters its thermodynamic status primarily by:
(A) Increasing its free energy and raising the water potential.
(B) Decreasing the pressure potential without affecting the solute potential.
(C) Decreasing its free energy and lowering the water potential.
(D) Increasing the matric potential of the solution.

2025

21. Which component of plant water potential is primarily responsible for the retention of water in highly organic or clay-rich dry soils?
(A) Matric potential
(B) Osmotic potential
(C) Gravity potential
(D) Pressure potential

2021

22. Arrange the following components of the Soil-Plant-Atmosphere Continuum (SPAC) in order of decreasing water potential (from highest to lowest) during active daytime transpiration:
I. Leaf mesophyll cells
II. Atmospheric air
III. Soil solution
IV. Root xylem
(A) III → IV → I → II
(B) III → I → IV → II
(C) II → I → IV → III
(D) IV → III → II → I

2006

23. Gravity potential (Ψ_g) is generally considered negligible in calculations of water potential for small plants because:
(A) Gravity only affects solute concentration, not water movement.
(B) It increases by only 0.01 MPa per meter of height.
(C) Root pressure easily overcomes any gravitational pull in all plants.
(D) Aquaporins counteract gravitational forces at the cellular level.

2003

24. Which of the following accurately describes the role of the osmotic potential (Ψ_s) component in a plant cell?
(A) It represents the physical pressure exerted by the cell wall.
(B) It is the primary driving force for the mass flow of water in xylem.
(C) It lowers the water potential due to dissolved solutes.
(D) It is always positive in well-watered physiological states.

NODIA

2009

25. Identify the INCORRECT pair regarding water potential components and their symbols:
(A) Solute potential — Ψ_s

the xylem can cause dissolved gases to rapidly come out of solution and expand.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019
46. An air embolism in a single xylem vessel element is usually prevented from spreading to adjacent vessels by:
(A) The active secretion of resins into the vessel.
(B) The immediate regeneration of the Casparian strip around the embolized vessel.
(C) Pit membranes with tiny pores that block air bubbles.
(D) The rapid influx of sucrose to increase osmotic pressure.

2017
47. Which phenomenon is considered direct visual evidence of root pressure operating in intact plants?
(A) Cavitation
(B) Plasmolysis
(C) Embolism
(D) Guttation

2017
48. Guttation typically occurs through specialized structures at the leaf margins known as:
(A) Lenticels
(B) Guard cells
(C) Hydathodes
(D) Trichomes

2021
49. The cohesion-tension mechanism requires the xylem conduits to possess high structural rigidity. This structural support is primarily provided by:
(A) Cellulose microfibrils in the primary cell wall.
(B) Lignification of the secondary cell walls.
(C) High turgor pressure within the mature vessel elements.
(D) The surrounding bundle sheath cells.

2022
50. During active daytime transpiration, the pressure potential (Ψ_p) of the xylem sap in a tall tree is typically:
(A) Positive and high
(B) Zero
(C) Equal to the osmotic potential of the sap
(D) Negative (under tension)

2008
51. Which factor contributes most significantly to the generation of the pulling force (tension) at the leaf level?
(A) Water evaporation from mesophyll cell walls into the substomatal cavity.
(B) The active transport of potassium ions and other inorganic solutes into the xylem.
(C) The closing of stomata during midday stress.
(D) The capillary rise of water in the phloem.

2012
52. What is the primary functional significance of the guard cells in plant water relations?
(A) They synthesize the majority of the leaf's abscisic acid.
(B) They physically pump water from the conducting xylem vessels into the leaf mesophyll.
(C) They regulate stomatal aperture to balance CO_2 uptake and water loss.
(D) They secrete cuticular waxes to reduce cuticular transpiration.

2009
53. The opening of stomata in light is primarily driven by the active accumulation of which osmotically active solute in the guard cell vacuoles?
(A) Potassium (K^+)
(B) Calcium ($Ca^{\{2+\}}$)
(C) Sodium (Na^+)
(D) Magnesium ($Mg^{\{2+\}}$)

2007
54. Along with potassium, which counter-ion commonly accumulates in guard cells during stomatal opening to maintain electrical neutrality?
(A) Sulfate
(B) Phosphate
(C) Nitrate
(D) Malate

2018
55. Match the instruments in List I with their primary physiological measurements in List II.
List I: Instruments
P. Pressure chamber (Scholander bomb)
Q. Thermocouple psychrometer
R. Osmometer
S. Infrared thermometer
List II: Primary physiological measurements
1. Canopy temperature
2. Leaf water potential

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Q. Catalase (CAT)
R. Ascorbate peroxidase (APX)
S. Glutathione reductase (GR)

List II: Specific substrates/functions

1. Disproportionates H_2O_2 into water and oxygen, primarily in peroxisomes
2. Reduces oxidized glutathione (GSSG) to maintain the redox state
3. Uses ascorbate as an electron donor to reduce H_2O_2 in chloroplasts
4. Catalyzes the dismutation of superoxide anion ($O_2^{\cdot-}$)

(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-1, S-3

2021

96. Which of the following is a key non-enzymatic antioxidant molecule involved in ROS detoxification during drought stress?
(A) Chlorophyll a
(B) Cytochrome c
(C) Ascorbic acid
(D) Phytochrome

2017

97. Water Use Efficiency (WUE) at the single-leaf level is defined as the ratio of:
(A) Transpiration rate to stomatal conductance.
(B) CO_2 assimilation rate to transpiration rate.
(C) Biomass accumulated to total water applied.
(D) Leaf area index to crop evapotranspiration.

2019

98. Consider the following statements concerning carbon isotope discrimination ($\Delta^{13}C$) as a surrogate trait for water use efficiency (WUE) in C_3 plants:
I. Rubisco discriminates against the heavier ${}^{\{13\}}CO_2$ isotope in favor of ${}^{\{12\}}CO_2$.
II. Lower $\Delta^{13}C$ in leaf dry matter generally correlates with higher long-term WUE.
III. Drought stress causing prolonged stomatal closure increases intercellular CO_2 and thus increases $\Delta^{13}C$.
IV. Carbon isotope discrimination is unrelated to stomatal conductance.
Which of the above statements is/are correct?
(A) I and II
(B) I, II and IV
(C) II and III
(D) I and III

NODIA

2023

99. Relative Water Content (RWC) is a widely used index for assessing plant water status. The standard formula for calculating RWC is:
(A) $\frac{\text{Fresh Weight} - \text{Dry Weight}}{\text{Turgid Weight} - \text{Dry Weight}} \times 100$
(B) $\frac{\text{Turgid Weight} - \text{Fresh Weight}}{\text{Dry Weight}} \times 100$
(C) $\frac{\text{Fresh Weight} - \text{Turgid Weight}}{\text{Fresh Weight} - \text{Dry Weight}} \times 100$
(D) $\frac{\text{Dry Weight} - \text{Fresh Weight}}{\text{Turgid Weight}} \times 100$

2013

100. A plant with a high capacity for cellular drought tolerance would most likely exhibit which phenotype when subjected to desiccation?
(A) Rapid reduction in RWC to below 50%.
(B) Immediate abscission of all leaves.
(C) High Cell Membrane Stability (CMS).
(D) Cessation of all antioxidant enzyme activities.

2018

101. The Cell Membrane Stability (CMS) test, used to screen for drought tolerance, relies on measuring:
(A) Electrolyte leakage from stressed leaf tissue.
(B) The rate of oxygen evolution from leaf discs.
(C) The structural thickness of the plasma membrane using electron microscopy.
(D) The accumulation of proline in the apoplast.

2018

102. In the CMS test, higher electrical conductivity in the bathing medium of drought-stressed leaf discs compared to the control indicates:
(A) Superior drought tolerance and intact membranes.
(B) High efficiency of ion pumps.
(C) Successful osmotic adjustment.
(D) Greater membrane damage.

2012

103. Which imaging technique is increasingly being utilized in high-throughput phenotyping platforms to non-destructively monitor plant water status and canopy temperature?
(A) Magnetic Resonance Imaging (MRI)
(B) Thermal Infrared (TIR) Imaging
(C) X-ray Crystallography
(D) Fluorescence In Situ Hybridization (FISH)

2016

104. The passive movement of water through the root system from wet, deeper soil layers to drier,

(D) High wind speed

2012

66. Plant hydraulic conductance refers to:
(A) The rate at which photosynthetic sugars are transported in the phloem.
(B) The ability of the stomata to restrict CO_2 efflux.
(C) The accumulation of compatible solutes in the roots.
(D) Efficiency of liquid water movement through the plant.

2005

67. During progressive drought stress, a decrease in plant hydraulic conductance is most frequently associated with:
(A) Xylem cavitation and embolism.
(B) Increased synthesis of root aquaporins.
(C) Enlargement of xylem vessel diameter.
(D) Enhanced apoplastic water flow in the root cortex.

2022

68. What is a common morphological response of plant roots to mild or moderate water deficit?
(A) Decreased primary root elongation.
(B) Complete shedding of all fine roots.
(C) Increased allocation of biomass to roots, raising root-to-shoot ratio.
(D) Transition from a taproot system to an exclusively adventitious root system.

2017

69. Leaf rolling in cereals during drought stress serves as an adaptive morphological response primarily by:
(A) Reducing leaf area exposed to solar radiation to limit transpiration.
(B) Increasing the effective leaf area for light absorption and photosynthesis.
(C) Exposing the stomata-rich abaxial surface to the sun.
(D) Enhancing the metabolic accumulation of protective reactive oxygen species.

2013

70. Stress-induced leaf senescence and abscission during severe drought benefit the plant by:
(A) Increasing the total carbon assimilation rate.
(B) Enhancing the physical transport of water and solutes from older leaves back to the soil.
(C) Preventing the synthesis of abscisic acid (ABA).
(D) Reducing transpirational surface area to conserve water for meristems.

2010

71. The phenomenon of altered root-shoot allometry under drought stress is heavily regulated by:
(A) Reduced levels of ethylene in the roots.
(B) Differential sensitivity of root and shoot growth to ABA.
(C) Increased biosynthesis of gibberellins within the expanding shoot apex.
(D) Enhanced cytokinin transport from the roots.

2017

72. Which physiological event is widely considered the earliest response of plants to water deficit?
(A) Osmotic adjustment
(B) Leaf senescence
(C) Stomatal closure
(D) Accumulation of LEA proteins

2021

73. Stomatal closure under drought stress directly results in a decrease in:
(A) The physiological production of reactive oxygen species within chloroplasts.
(B) The synthesis of abscisic acid (ABA) in leaves.
(C) The water potential of the bulk soil.
(D) Intercellular CO_2 concentration and carbon assimilation.

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2009

74. How does severe water deficit typically affect phloem transport?
(A) It impairs transport due to decreased turgor in sieve elements.
(B) It increases the rate of phloem loading due to higher sucrose concentration.
(C) It causes the phloem to reverse flow, bringing water from roots to shoots.
(D) It replaces symplastic loading with apoplastic loading universally.

2007

75. Identify the INCORRECT statement regarding the biochemical responses of plants to water deficit.
(A) Drought stress triggers an overproduction of Reactive Oxygen Species (ROS) in chloroplasts and mitochondria.
(B) Water deficit decreases the expression of antioxidant enzymes.
(C) ROS accumulation can lead to lipid peroxidation and membrane damage.
(D) ABA serves as a crucial signaling molecule

mediating both stomatal closure and gene expression.

2001

76. Reactive Oxygen Species (ROS) generated during drought stress include all of the following EXCEPT:
(A) Superoxide anion
(B) Carbon dioxide
(C) Hydrogen peroxide
(D) Hydroxyl radical

2014

77. The primary phytohormone responsible for mediating systemic stress signaling and stomatal closure during drought is:
(A) Abscisic acid (ABA)
(B) Auxin (IAA)
(C) Cytokinin
(D) Salicylic acid (SA)

2009

78. In the ABA-mediated signaling pathway in guard cells, the binding of ABA to its receptor (PYR/PYL/RCAR) directly leads to the inhibition of:
(A) SnRK2 kinases
(B) SLAC1 anion channels
(C) Type 2C protein phosphatases (PP2Cs)
(D) Calcium-dependent protein kinases (CDPKs)

2006

79. Which strategy is characterized by a plant completing its life cycle before the onset of a severe dry period?
(A) Drought tolerance
(B) Drought avoidance
(C) Drought recovery
(D) Drought escape

2016

80. Ephemeral plants found in desert ecosystems are classic examples of plants utilizing which drought adaptation strategy?
(A) Drought tolerance
(B) Drought avoidance
(C) Drought escape
(D) Osmotic adjustment

2005

81. Drought avoidance refers to the ability of a plant to:
(A) Function effectively while its internal tissues undergo severe dehydration.
(B) Maintain water potential despite environmental water shortage.
(C) Accelerate its phenological development to reproduce early.
(D) Enter a state of cryptobiosis during dry spells.

2003

82. Which of the following is considered a mechanism of drought avoidance?
(A) Accumulation of proline in the cytoplasm.
(B) Synthesis of Late Embryogenesis Abundant (LEA) proteins.
(C) Enhanced efficiency of the ascorbate-glutathione cycle.
(D) Development of a deep and extensive root system.

2001

83. Increased deposition of cuticular waxes on the leaf epidermis contributes to drought adaptation by:
(A) Reducing non-stomatal transpiration when stomata are closed.
(B) Reflecting photosynthetically active radiation (PAR) to increase photosynthesis.
(C) Increasing the boundary layer resistance for better CO_2 diffusion.
(D) Facilitating the rapid absorption of atmospheric dew.

2010

84. Altered phenology as a drought adaptation mechanism most commonly manifests as:
(A) Delayed flowering to wait for favorable moisture.
(B) Prolonged duration of the grain-filling period.
(C) Accelerated transition to the reproductive stage.
(D) Inhibition of senescence to maintain green leaf area indefinitely.

2022

85. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Deep-rooted crops generally exhibit better drought avoidance than shallow-rooted crops.
Reason (R): Deep root systems can access moisture from deeper soil profiles that remain hydrated after surface layers dry out.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

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(D) A is false but R is true.

2015
86. Drought tolerance is strictly defined as the plant's capability to:
(A) Maintain high tissue water status by increasing water uptake.
(B) Prevent water loss completely through stomatal closure.
(C) Complete its life cycle before water deficit occurs.
(D) Endure low water potential and cellular dehydration.

2007
87. Osmotic adjustment (OA) is a key cellular mechanism of drought tolerance. It is achieved primarily by:
(A) The passive concentration of cellular solutes due to water loss.
(B) Active net accumulation of compatible solutes.
(C) The rapid polymerization of sugars into insoluble starch.
(D) The exclusion of all inorganic ions from the vacuole.

2008
88. Consider the following statements regarding compatible solutes (osmolytes):
I. They accumulate in the cytoplasm to lower osmotic potential.
II. They heavily interfere with normal enzymatic functions even at moderate concentrations.
III. They protect cellular structures, including membranes and proteins, from dehydration damage.
Which of the above statements is/are INCORRECT?
(A) I and III
(B) II and III
(C) II
(D) I

2019
89. Which of the following organic compounds does NOT typically serve as a compatible solute during osmotic adjustment?
(A) Proline
(B) Glycine betaine
(C) Trehalose
(D) Lignin

2017
90. The physiological benefit of osmotic adjustment during water deficit is that it helps the cell to:
(A) Maintain turgor and volume at lower water potential.
(B) Raise its solute potential to a significantly positive value.
(C) Rapidly senesce to conserve water.
(D) Eliminate the need for aquaporins.

NODIA

2005
91. The accumulation of proline during drought stress is regulated primarily through the up-regulation of which key biosynthetic enzyme?
(A) Proline dehydrogenase (PDH) involved in proline catabolism
(B) Δ^1-pyrroline-5-carboxylate synthetase (P5CS)
(C) Nitrate reductase (NR)
(D) Rubisco

2008
92. Late Embryogenesis Abundant (LEA) proteins were originally discovered in maturing seeds but are also synthesized in vegetative tissues under drought. Their primary proposed function is to:
(A) Act as proteases to degrade damaged proteins.
(B) Serve as chaperones to prevent protein aggregation.
(C) Actively transport water across the plasma membrane.
(D) Synthesize compatible solutes like glycine betaine.

2004
93. Dehydrins are a specific and well-characterized sub-family of:
(A) LEA proteins (Group II)
(B) Aquaporins (Group IV)
(C) Antioxidant enzymes
(D) Photosynthetic electron carriers

2024
94. The enzymatic antioxidant defense system, crucial for scavenging ROS during drought, heavily relies on which of the following enzymes to convert superoxide radicals into hydrogen peroxide?
(A) Catalase (CAT)
(B) Ascorbate peroxidase (APX)
(C) Superoxide dismutase (SOD)
(D) Glutathione reductase (GR)

2016
95. Match the antioxidant enzymes in List I with their specific substrates/functions in List II.
List I: Antioxidant enzymes
P. Superoxide dismutase (SOD)

(A) Just prior to sunrise
(B) Mid-to-late afternoon
(C) Late evening after sunset
(D) Around midnight hours

2008
114. The driving force for the imbibition of water by a dry seed is primarily driven by a highly negative:
(A) Pressure potential
(B) Solute potential
(C) Gravity potential
(D) Matric potential

2021
115. A decrease in the size of the boundary layer around a leaf due to increased wind speed will generally result in:
(A) Enhanced transpiration due to decreased boundary resistance.
(B) Decreased transpiration rates caused by rapid stomatal closure.
(C) A substantial increase in the overall leaf surface temperature.
(D) A marked reduction in photosynthetic carbon dioxide uptake.

2009
116. In the cohesion-tension theory, "cavitation" refers specifically to:
(A) The active repair of an embolized vessel by nearby parenchyma cells.
(B) The continuous radial movement of water across the Casparian strip.
(C) The rupture of the water column and its filling with air or vapor.
(D) The physiological secretion of liquid water droplets from hydathodes.

2023
117. Which of the following structural features makes tracheids generally less susceptible to cavitation than large vessel elements?
(A) Their narrower diameter and pit membranes which effectively isolate bubbles.
(B) They possess living protoplasts that actively pump out structural air bubbles.
(C) They completely lack secondary wall thickenings, rendering them more flexible.
(D) They are situated exclusively in the phloem tissue where tension is absent.

2023
118. Which statement about the symplastic pathway is INCORRECT?
(A) It represents the continuum of cytoplasm interconnected by plasmodesmata.
(B) It offers higher resistance to water flow compared to the apoplastic pathway.
(C) It bypasses the selective barrier of the plasma membrane entirely after initial entry.
(D) It is completely blocked by the Casparian strip in the endodermis.

2023
119. The "transmembrane pathway" of water transport across root tissues heavily relies on the density and activity of:
(A) Plasmodesmata
(B) Aquaporins
(C) Xylem pits
(D) Casparian bands

2005
120. Which plant physiological process is the primary cause of the "atmospheric evaporative demand"?
(A) The active process of stomatal transpiration from leaves.
(B) The passive evaporation of water directly from the soil.
(C) The vapor pressure deficit (VPD) of the surrounding air.
(D) The dynamic changes in root hydraulic conductance values.

2015
121. Under well-watered conditions, the osmotic potential of a typical mesophyll cell is approximately -1.5 MPa and its turgor pressure is 0.7 MPa. What is its water potential?
(A) -2.2 MPa
(B) +0.8 MPa
(C) -1.5 MPa
(D) -0.8 MPa

2007
122. If a mesophyll cell with Ψ_w = -0.8 MPa is surrounded by apoplastic fluid with Ψ_w = -1.0 MPa, what will occur?
(A) The cell will lose water and its turgor pressure will decrease.
(B) The cell will gain water and its turgor pressure will increase.
(C) Water movement between the cell and apoplast will reach dynamic equilibrium.
(D) The cell will actively pump solutes out to equilibrate.

2016
123. A plant experiencing "physiological drought" is most likely situated in an environment where:
(A) The soil environment is completely devoid of water from lack of rainfall.

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shallower soil layers during the night is known as:
(A) Hydraulic lift
(B) Root pressure
(C) Capillary rise
(D) Stem flow

2022
105. Which of the following physical factors dictates the rate of diffusion of water vapor out of a stoma?
(A) The specific heat of the surrounding air.
(B) Active physiological transport of water vapor by localized guard cells.
(C) The matric potential of the guard cell walls.
(D) The water vapor concentration gradient between leaf and air.

2014
106. A key distinction between osmosis and diffusion is that osmosis strictly involves:
(A) The movement of a solvent across a differentially/selectively permeable membrane.
(B) The movement of solutes across a completely impermeable membrane.
(C) The expenditure of metabolic energy (ATP).
(D) Movement exclusively against a concentration gradient.

2022
107. When a plant cell becomes fully turgid, its Diffusion Pressure Deficit (DPD) becomes:
(A) Equal to its osmotic pressure
(B) Zero
(C) Maximum
(D) Equal to its wall pressure

2016
108. Select the correct combination of statements concerning the Soil-Plant-Atmosphere Continuum (SPAC):
I. Water movement through the SPAC is driven by a continuous gradient of decreasing water potential.
II. The gradient moves from relatively high water potential in the soil to very low water potential in the atmosphere.
III. Resistance to water flow within the SPAC is uniform across all plant organs.
IV. Phase change from liquid to vapor occurs primarily in the substomatal cavities.
V. Atmospheric humidity has no substantial impact on the water potential gradient of the SPAC.
Which of the above statements are correct?
(A) I, II, III and IV
(B) I, II and IV
(C) II, IV and V
(D) I, III and V

NODIA

2011
109. Which physiological metric is the most sensitive and immediate indicator of mild soil water deficit?
(A) Decrease in leaf stomatal conductance
(B) Wilting of older leaves
(C) Accumulation of compatible solutes
(D) Formation of xylem embolisms

2025
110. Which class of hormones acts antagonistically to ABA in the regulation of stomatal movement, generally promoting stomatal opening?
(A) Brassinosteroids
(B) Jasmonates
(C) Cytokinins
(D) Ethylene

2004
111. During root water uptake, what generates the positive hydrostatic pressure known as root pressure?
(A) The metabolic pumping of water molecules across root cortical cell layers.
(B) The physical capillary rise of water within the narrow xylem vessels.
(C) The mechanical contraction of the endodermal Casparian strip structures.
(D) The active accumulation of ions in xylem sap that osmotically draws water.

2016
112. The structural property of water that gives rise to its unique thermal properties, such as high specific heat and high latent heat of vaporization, is:
(A) Its low molecular weight and simple atomic arrangement.
(B) Its partial dissociation into hydrogen and hydroxyl ions.
(C) Its extensive intermolecular hydrogen bonding.
(D) Its net neutral pH and lack of net electrical charge.

2013
113. Under clear, sunny conditions with adequate soil moisture, leaf water potential usually reaches its lowest (most negative) value at what time of day?

cell turgor.
(D) Passive loss of water from the cell without any biochemical changes.

2012
133. Compatible solutes (osmolytes) share several common biochemical characteristics. Which of the following is NOT one of them?
(A) They strongly inhibit key metabolic enzymes.
(B) They are highly soluble in water.
(C) They carry a net neutral charge at physiological pH.
(D) They are typically low molecular weight organic compounds.

2001
134. Which class of protective proteins, characterized by high hydrophilicity and lack of stable secondary structure in fully hydrated states, accumulates heavily during cellular desiccation?
(A) Heat Shock Proteins (HSPs)
(B) Aquaporins
(C) Cytochromes
(D) LEA proteins

2004
135. Match the drought adaptation mechanisms in List I with their appropriate category in List II.
List I: (Drought adaptation mechanisms)
P. Early flowering
Q. Deep root system
R. Osmotic adjustment
S. Increased cuticular wax
List II: (Category)
1. Drought tolerance
2. Drought escape
3. Drought avoidance (water uptake)
4. Drought avoidance (water conservation)
(A) P-2, Q-4, R-1, S-3
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-3, R-2, S-4

2002
136. The term "phenotyping" in the context of drought physiology refers to:
(A) Sequencing the entire genome of highly drought-tolerant plant species.
(B) Successfully introducing drought-responsive genes via transgenics.
(C) Assessing observable physical and physiological traits of the plant.
(D) Identifying the specific alleles responsible for cellular osmotic adjustment.

2005
137. Which of the following is considered an indirect, high-throughput surrogate trait for selecting plants with high stomatal conductance and deep roots under drought?
(A) Proline quantification via spectrophotometry.
(B) Measurement of individual root lengths via excavation.
(C) Determination of sap osmotic potential using an osmometer.
(D) Canopy temperature measured by infrared thermometry.

2017
138. If two crop varieties are subjected to severe drought, and Variety A maintains a Relative Water Content (RWC) of 80% while Variety B drops to 60%, Variety A most likely possesses better:
(A) Mechanisms for drought avoidance.
(B) Rates of cuticular transpiration.
(C) Sensitivity to ROS-induced damage.
(D) Tendency for xylem cavitation.

2015
139. High Cell Membrane Stability (CMS) during drought stress is primarily attributed to:
(A) Increased proportions of saturated fatty acids in membrane lipids.
(B) Antioxidant defense systems and protective osmolytes.
(C) The complete replacement of phospholipids with galactolipids.
(D) The breakdown of structural membrane proteins.

2012
140. Which specific component of the antioxidant defense system is located strictly within the ascorbate-glutathione cycle?
(A) Superoxide dismutase enzyme
(B) Dehydroascorbate reductase
(C) Hydrogen peroxide catalase
(D) Nonspecific peroxidase

2011
141. The accumulation of hydrogen peroxide (H_2O_2) in plant cells is dual-natured because it can act as:
(A) A signaling molecule at low levels and a toxin at high levels.
(B) Both a protective compatible solute and a highly destructive toxic radical.
(C) Both a vital structural cell wall component and a metabolic enzyme inhibitor.
(D) Both a specific hormone receptor and a

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(B) Soil water is present but unavailable due to salinity or cold.
(C) The relative humidity of the surrounding atmosphere is extremely high.
(D) The plant canopy temperature remains lower than the surrounding air.

2022

124. Crop temperature, as measured by infrared thermometry, integrates the effects of several physiological traits. A genotype maintaining a cooler canopy under drought is typically inferred to have:
(A) Shallower roots and closed stomata.
(B) Deeper roots sustaining transpiration.
(C) Inherently lower rates of photosynthesis.
(D) Thicker cuticular wax layers reflecting heat.

2022

125. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Stomatal closure during early drought stress decreases water loss but also invariably reduces crop growth.
Reason (R): Stomatal closure restricts the influx of CO_2 into the leaf, thereby limiting the rate of photosynthetic carbon assimilation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

126. During progressive drought stress, plant root morphology often changes. Which morphological change is most advantageous for drought avoidance?
(A) Proliferation of fine lateral roots in the drying upper soil layers.
(B) Complete suberization of all root tips to prevent water loss.
(C) Deep root penetration and branching in deeper soil horizons.
(D) The structural conversion of tap roots into specialized storage organs.

2006

127. Which physiological consequence of drought stress is primarily responsible for the impairment of phloem loading?
(A) Increased metabolic availability of ATP in the companion cells.
(B) Overexpression of specific active sucrose-proton symporters.
(C) The physical expansion of sieve tube elements in the phloem.
(D) Reduced sucrose production and loss of mesophyll turgor.

2004

128. ABA-mediated stress signaling involves the rapid increase of which secondary messenger in the guard cell cytoplasm, leading to the opening of anion channels?
(A) Cyclic AMP (cAMP)
(B) Inositol triphosphate (IP_3)
(C) Calcium ions ($Ca^{\{2+\}}$)
(D) Nitric oxide (NO)

2009

129. The synthesis of abscisic acid (ABA) during drought stress primarily occurs in the:
(A) Mitochondria
(B) Plastids and cytoplasm
(C) Nucleus
(D) The endoplasmic reticulum

2023

130. The "drought escape" strategy is most typically observed in:
(A) Desert succulents (e.g., Cacti)
(B) Deep-rooted trees (e.g., Mesquite)
(C) Evergreen conifers
(D) Ephemeral annuals

NODIA

2008

131. Which of the following best differentiates drought avoidance from drought tolerance?
(A) Avoidance maintains hydration, while tolerance enables survival when dehydrated.
(B) Avoidance involves completing the lifecycle early, whereas tolerance specifically involves developing deep roots.
(C) Avoidance strictly requires osmotic adjustment, whereas tolerance relies primarily on thick cuticular waxes.
(D) There is no functional difference; they are synonymous terms.

2005

132. Osmotic adjustment differs from simple cellular dehydration (passive concentration of solutes) because osmotic adjustment involves:
(A) A significant, passive decrease in total cellular solute content.
(B) The rapid structural breakdown of the large central vacuole.
(C) Active accumulation of solutes to maintain

3. Osmotic potential of cell sap
4. Water potential (via vapor pressure equilibration)

(A) P-2, Q-4, R-3, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-3, R-4, S-1

2014

56. Which of the following is an INCORRECT statement regarding leaf diffusive resistance?
(A) It consists of both stomatal resistance and boundary layer resistance.
(B) A thicker boundary layer increases resistance to water vapor diffusion.
(C) Stomatal resistance decreases under severe water deficit.
(D) High wind speed typically decreases boundary layer resistance.

2010

57. The primary principle behind the pressure chamber (Scholander bomb) technique is to:
(A) Measure the osmotic pressure of extracted xylem sap.
(B) Freeze the tissue and measure the melting point depression.
(C) Measure the relative humidity inside a sealed chamber containing the leaf.
(D) Apply gas pressure to a leaf until sap appears, balancing tension.

2015

58. Psychrometry determines tissue water potential by measuring:
(A) Wet-bulb depression in a chamber equilibrated with the tissue.
(B) The pressure required to extract sap from the tissue.
(C) The freezing point depression of sap extracted from the cellular tissue.
(D) The rate of sap flow through the stem.

2021

59. Vapor pressure osmometry is most appropriately used to determine which specific component of water potential in an expressed sap sample?
(A) Pressure potential
(B) Osmotic potential
(C) Matric potential
(D) Gravity potential

2016

60. Canopy Temperature Depression (CTD) is frequently used in crop phenotyping. CTD is calculated as:
(A) Canopy temperature plus Air temperature
(B) Air temperature minus Canopy temperature
(C) Canopy temperature divided by Air temperature
(D) Air temperature divided by Canopy temperature

2022

61. A positive and high Canopy Temperature Depression (CTD) value (i.e., canopy is much cooler than the air) generally indicates:
(A) High transpiration and good crop water status.
(B) Severe drought stress resulting in stomatal closure.
(C) High leaf diffusive resistance.
(D) Impaired root hydraulic conductance.

2013

62. Which physiological mechanism directly links canopy temperature to water status?
(A) Imbibition of atmospheric moisture by the cuticle.
(B) Exothermic reactions during dark respiration in leaves.
(C) Evaporative cooling resulting from transpirational water loss.

2010

63. Infrared thermometry measures canopy temperature remotely by detecting:
(A) The reflection of visible light from the leaf surface.
(B) The absorption of ultraviolet light by leaf pigments.
(C) The specific heat capacity of the leaf tissue.
(D) Thermal radiation emitted by the crop canopy.

2023

64. The development of crop water deficit is primarily a function of an imbalance between:
(A) Photosynthesis and respiration.
(B) Active mineral nutrient uptake and subsequent phloem loading.
(C) Water supply and atmospheric evaporative demand.
(D) Root growth and shoot allometry.

2003

65. Which of the following environmental variables does NOT directly increase atmospheric evaporative demand?
(A) High air temperature
(B) High soil moisture
(C) Low relative humidity

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primary chloroplast electron acceptor.

2001

142. The initial perception of soil drying by the root system often triggers a non-hydraulic signal to the shoots. This signal is widely recognized as being transported via the:
(A) Phloem sap, primarily in the form of sucrose.
(B) Apoplast, primarily in the form of calcium waves.
(C) Xylem sap, primarily in the form of ABA.
(D) Symplast, primarily in the form of electrical action potentials.

2002

143. Which of the following factors would decrease the transpiration rate of a single isolated leaf?
(A) A substantial increase in leaf temperature.
(B) Increase in the vapor pressure deficit (VPD) of the air.
(C) An increase in the total stomatal aperture.
(D) Increase in the surrounding air relative humidity.

2005

144. Water moves from the soil into the root xylem against gravity. According to the cohesion-tension theory, the energy required for this movement ultimately comes from:
(A) ATP hydrolyzed in the root endodermis.
(B) The electrochemical gradient of potassium ions.
(C) Solar energy driving leaf evaporation.
(D) Respiration in the stem xylem parenchyma.

2014

145. Plasmolysis of a plant cell can be experimentally reversed by:
(A) Placing the cell in a hypotonic solution (e.g., pure water).
(C) Injecting ABA into the cytoplasm.
(D) Removing the cell wall completely.

2002

146. A pressure chamber measures leaf water potential. A higher (more positive) gauge pressure required to express sap from the petiole indicates:
(A) A higher (less negative) leaf water potential.
(B) Complete lack of hydrostatic tension in the xylem conduits.
(C) Highly elevated rates of active companion cell phloem loading.
(D) A lower (more negative) leaf water potential.

2024

147. Under well-watered conditions, the value of the matric potential (Ψ_m) in fleshy plant tissues is generally:
(A) Close to zero and generally ignored in calculations.
(B) Highly negative and the dominant component of water potential.
(C) Positive and functionally equivalent to cell turgor pressure.
(D) Mathematically equal to the internal osmotic potential.

2005

148. Select the correct sequence of the ABA signaling cascade leading to stomatal closure:
(A) ABA binding to PYR/PYL $\rightarrow$ Activation of SnRK2 $\rightarrow$ Inhibition of PP2C $\rightarrow$ Activation of SLAC1
(B) Activation of SLAC1 $\rightarrow$ Inhibition of PP2C $\rightarrow$ Activation of SnRK2 $\rightarrow$ ABA binding to PYR/PYL
(C) ABA binding to PYR/PYL $\rightarrow$ Inhibition of PP2C $\rightarrow$ Activation of SnRK2 $\rightarrow$ Activation of SLAC1
(D) Inhibition of PP2C $\rightarrow$ ABA binding to PYR/PYL $\rightarrow$ Activation of SnRK2 $\rightarrow$ Activation of SLAC1

2008

149. The specific heat of water is high due to the extensive hydrogen bonding network. Biologically, this is important because:
(A) It buffers plants against rapid temperature fluctuations.
(B) It provides structural rigidity to non-woody plants.
(C) It facilitates the dissolving of non-polar molecules.
(D) It creates a high surface tension allowing insects to walk on water.

2019

150. Which structural property dictates the dipole nature of a water molecule?
(A) The perfectly linear arrangement of the constituent hydrogen and oxygen atoms.
(B) The chemical presence of two polar ionic bonds between hydrogen and oxygen.
(C) The perfectly equal sharing of covalent electrons between hydrogen and oxygen.
(D) The 104.5-degree angle and oxygen's high electronegativity.

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2013

209. Carbon isotope discrimination ($\Delta^{13}C$) in C_3 plants correlates well with Water Use Efficiency (WUE). A genotype with a lower $\Delta^{13}C$ value typically indicates:

(A) Significantly lower WUE and higher stomatal conductance rates.

(B) Higher WUE and lower internal CO_2 concentration.

(C) The plant possesses a fully functional C_4 photosynthetic pathway.

(D) Complete and irreversible lack of Rubisco enzymatic activity.

2021

210. Which technique would be most appropriate for high-throughput, non-destructive field phenotyping of crop water status across hundreds of breeding plots simultaneously?

(A) Extracting leaf sap for osmometry under controlled conditions.

(B) Individual leaf water potential measurements using a pressure chamber.

(C) Laboratory-based Cell Membrane Stability (CMS) assays on leaf punches.

(D) Aerial thermal imaging to measure canopy temperature depression.

NODIA

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(C) Remain unchanged
(D) Shift to active phloem loading

2021
162. Active water absorption relies on the accumulation of solutes in the root xylem. This creates a hypertonic condition in the stele that draws water across the root. The barrier that prevents these solutes from leaking back into the cortex is the:
(A) Outer epidermis
(B) Exodermis
(C) Pericycle
(D) Endodermis

2016
163. The Casparian strip forces apoplastic water to enter the symplast by crossing a plasma membrane. This transition is essential because it allows the root to:
(A) Regulate selective ion uptake and block toxins.
(B) Generate the physical tension required for transpiration.
(C) Synthesize protective LEA proteins efficiently.
(D) Expel dissolved oxygen back into the soil.

2013
164. Which anatomical feature is critical to preventing the catastrophic spread of an embolism through the entire xylem network of a tree?
(A) The lack of end walls in vessel elements.
(B) The rigid secondary cell wall composed of lignin.
(C) Bordered pits or micro-porous pit membranes.
(D) The continuous nature of the sieve tube elements.

2024
165. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Root pressure alone cannot account for the ascent of sap in tall trees like redwoods.
Reason (R): The magnitude of root pressure typically does not exceed 0.2 to 0.5 MPa, which can only push water a few meters high.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014
166. Stomatal transpiration accounts for the vast majority of water loss in plants. However, a small percentage of water is lost directly through the leaf surface epidermis. This is termed:
(A) Lenticular transpiration
(B) Guttation
(C) Secretory loss
(D) Cuticular transpiration

2015
167. During drought, an increase in the thickness of the leaf boundary layer would theoretically:
(A) Significantly increase the overall transpiration rates.
(B) Decrease transpiration rates by adding resistance.
(C) Have no noticeable physical effect on transpiration.
(D) Directly increase the leaf internal osmotic potential.

2007
168. Select the INCORRECT combination of statements regarding stomatal physiology:
I. Guard cells have unevenly thickened cell walls, with the inner wall being thicker.
II. Radially oriented cellulose microfibrils in guard cells restrict longitudinal expansion, causing them to bow outward when turgid.
III. Stomatal opening is driven by the active efflux of potassium ions out of the guard cells.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) II and III
(C) III
(D) I

2006
169. Thermocouple psychrometry relies on the principle of:
(A) Measuring the depression of the physical freezing point of plant sap.
(B) Applying external pressurized gas to exactly balance the xylem tension.
(C) Emitting infrared radiation to measure the leaf reflectance properties.
(D) Measuring the evaporative cooling effect in a sealed chamber.

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2001

151. Imbibition is essentially a special type of diffusion where water movement is driven by a gradient of:
(A) Osmotic potential
(B) Matric potential
(C) Pressure potential
(D) Gravity potential

2024

152. Imbibition pressure can be extraordinarily high. In natural environments, this pressure is vital for:
(A) The upward flow of water in a 100-meter-tall tree.
(B) Opening of stomata during dawn.
(C) Breaking the seed coat during early germination.
(D) Pushing sucrose into the phloem sieve elements.

2004

153. Osmotic pressure (OP) of a solution is defined as the:
(A) Actual hydrostatic pressure present within the solution.
(B) Maximum pressure that can be developed if the solution is separated from pure water by a perfectly semi-permeable membrane.
(C) Negative value of the solute potential.
(D) Both (B) and (C) are correct definitions/ relations.

2011

154. What is the fundamental physiological effect of mild water stress on cell growth?
(A) Cell expansion is inhibited long before photosynthesis declines.
(B) Cell division completely ceases while physical cell expansion continues.
(C) Cell wall structural synthesis accelerates to protect the protoplast.
(D) Vacuoles rapidly fragment into smaller vesicles to boost surface area.

2022

155. Which statement accurately describes the relationship between DPD (Diffusion Pressure Deficit) and water potential (Ψ_w)?
(A) DPD and Ψ_w are numerically equal and have the same sign.
(B) DPD is equal to Ψ_w but has an opposite sign.
(C) DPD measures pressure, whereas Ψ_w measures volume.
(D) There is no direct mathematical relationship between them.

NODIA

2021

156. The water potential of a fully turgid cell is zero because:
(A) The osmotic potential is zero.
(B) Pressure potential cancels osmotic potential.
(C) The pressure potential is zero.
(D) The lipid cell membrane becomes completely impermeable to water molecules.

2016

157. Which component of water potential is negative in the xylem of a transpiring plant but positive in the phloem of a photosynthesizing leaf?
(A) Pressure potential
(B) Internal osmotic potential
(C) Matric potential
(D) Gravity potential

2015

158. Aquaporins are known to be highly regulated. Which environmental condition is most likely to cause the rapid phosphorylation and activation of aquaporins?
(A) Severe environmental drought stress
(B) Soil flooding and root hypoxia
(C) Abundant water availability
(D) Cellular heavy metal toxicity

2024

159. The regulation of root hydraulic conductance during diurnal cycles is closely correlated with the abundance and activity of which specific aquaporin subfamily?
(A) Tonoplast Intrinsic Proteins (TIPs)
(B) Nodulin-26 like Intrinsic Proteins (NIPs) of the membrane
(C) Small basic Intrinsic Proteins (SIPs)
(D) Plasma membrane Intrinsic Proteins (PIPs)

2005

160. Within the SPAC, the most dramatic drop in water potential (the steepest gradient) occurs between the:
(A) The bulk soil and outer root epidermis.
(B) The root xylem vessels and stem xylem.
(C) Leaf air spaces and the atmosphere.
(D) The stem xylem and surrounding leaf mesophyll.

2003

161. Passive water absorption is proportional to the rate of transpiration. If a plant is placed in an atmosphere with 100% relative humidity, passive absorption will:
(A) Increase significantly
(B) Decrease to near zero

directly to O_2. This forms which specific primary ROS?
(A) Superoxide radical
(B) Hydrogen peroxide molecule
(C) Hydroxyl radical (OH)
(D) Singlet oxygen ($^1O_2$)

2023
180. Singlet oxygen ($^1O_2$) is another highly toxic ROS generated during drought stress. It is primarily produced in which cellular compartment?
(A) The mitochondrial matrix during respiration.
(B) The peroxisome during photorespiration.
(C) The photosystem II reaction center.
(D) The apoplast by plasma membrane oxidases.

2002
181. ABA-induced stomatal closure is an example of which drought adaptation strategy?
(A) Drought avoidance
(B) Cellular drought tolerance
(C) Drought escape
(D) Drought recovery

2001
182. A classic mechanism of drought avoidance via maintaining water uptake involves the modification of Root System Architecture (RSA). A drought-adapted RSA typically exhibits:
(A) A shallow, highly branched root system restricted to the topsoil.
(B) The complete absence of lateral roots.
(C) Highly suberized roots that are entirely impermeable to water.
(D) A deep taproot with steep growth angles.

2015
183. The developmental plasticity of root phenology, where roots continue to grow downward while shoot growth is arrested during drought, is functionally termed:
(A) Positive hydrotropism
(B) Allometric shifting
(C) Gravitropism
(D) Thigmotropism

2015
184. The physiological capability of a plant to maintain cellular turgor despite declining leaf water potential is the hallmark of:
(A) Cuticular resistance
(B) Leaf rolling
(C) Osmotic adjustment
(D) Embolism repair

2017
185. In osmotic adjustment, which of the following acts as the primary compatible osmolyte in members of the Chenopodiaceae family (e.g., sugar beet) under drought and salinity?
(A) Trehalose
(B) Fructan
(C) Sorbitol
(D) Betaine

2013
186. Which structural feature of Late Embryogenesis Abundant (LEA) proteins enables them to function as cellular protectants during extreme dehydration?
(A) They are intrinsically disordered and fold only upon target interaction.
(B) They possess rigid, highly structured hydrophobic cores that resist cellular folding.
(C) They contain active, highly specific catalytic sites that physically degrade ROS.
(D) They act as rigid, selective water channels or pores in the lipid bilayer membrane.

2022
187. In addition to LEA proteins, another class of highly hydrophilic proteins known as dehydrins accumulates in response to drought. Dehydrins are characterized biochemically by the presence of a conserved sequence called the:
(A) Zinc finger motif
(B) K-segment
(C) Leucine zipper
(D) WD40 repeat

2015
188. Select the correct combination of statements regarding plant antioxidant systems under drought:
I. Superoxide dismutase (SOD) acts as the first line of defense against ROS.
II. Catalase (CAT) primarily detoxifies H_2O_2 in peroxisomes without requiring a reducing equivalent.
III. Ascorbate peroxidase (APX) requires ascorbate to reduce H_2O_2 to water.
IV. Glutathione reductase (GR) uses ATP directly to reduce H_2O_2.
V. Alpha-tocopherol functions as a lipid-soluble non-enzymatic antioxidant protecting membranes.
Which of the above statements are correct?
(A) I, II, IV and V
(B) I, II, III and V
(C) II, III, IV and V

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vapor inside the humid substomatal cavities of leaves moves out into the drier surrounding atmosphere. This spontaneous movement occurs purely down a concentration gradient through the open stomata without requiring direct cellular energy expenditure.

10. (A) The turgor pressure is zero, and the protoplast begins to recede from the cell wall.
Incipient plasmolysis represents the precise stage of cellular water loss where turgor pressure drops exactly to zero. At this critical threshold, the protoplast just begins to pull away from the corners of the cell wall. It is an important physiological state used to experimentally determine the internal osmotic potential of plant tissue samples.

11. (B) $DPD = \text{Osmotic Pressure (OP)} - \text{Turgor Pressure (TP)}$
Diffusion Pressure Deficit represents the actual power of a cell to absorb water. It is determined by subtracting the outward turgor pressure, which resists water entry, from the inward osmotic pressure, which drives water absorption. This relationship governs passive water movement between cells, with water always flowing from a lower deficit to a higher deficit.

12. (B) Flaccidity of the guard cell and stomatal closure.
Guard cells control stomatal movement through changes in turgor pressure. When guard cells lose water, their turgor pressure decreases, causing them to become flaccid. The elastic inner walls of the guard cells return to their original straight shape, which brings the opposing outer walls closer together, effectively closing the stomatal aperture and reducing further transpirational water loss.

13. (A) The cell has lower water potential than the surrounding pure water.
Water always moves spontaneously from a region of higher water potential to a region of lower water potential. Pure water is defined as having the maximum possible water potential of zero. Because a flaccid cell contains dissolved solutes, its water potential is negative, creating a thermodynamic gradient that drives water into the cell until equilibrium is reached.

14. (C) They are equal in magnitude but opposite in direction.
Turgor pressure is the hydrostatic force exerted outward by the swelling protoplast against the cellular boundary. In response, the rigid cellulosic cell wall exerts an equal and opposite force, termed wall pressure, inward against the protoplast. Under steady-state conditions in a fully turgid cell, these two opposing physical forces are perfectly balanced in magnitude.

15. (B) P-3, Q-4, R-1, S-2
Osmosis describes water movement across selective membranes, whereas plasmolysis denotes protoplast shrinkage due to water exiting the vacuole. Turgor pressure represents the hydrostatic force acting against the enclosing cell wall. Imbibition is the physical adsorption of water molecules by dry hydrophilic materials. Recognizing these distinct physiological definitions is essential for analyzing cellular water relations and transport dynamics.

NODIA

16. (B) 0 MPa
By international scientific convention, the chemical potential of pure water at standard temperature and atmospheric pressure is defined as zero Megapascals. This standard serves as the reference point for all water potential measurements. The addition of solutes or application of tension lowers this free energy, resulting in negative water potential values in plant cells and soils.

17. (B) Megapascal
The standard International System unit designated for measuring plant water potential is the Megapascal, which represents a unit of pressure. One Megapascal is equivalent to ten bars of pressure. Utilizing pressure units allows plant physiologists to easily quantify the thermodynamic state of water and predict the direction of water movement through the soil-plant system.

18. (B) I and IV
Water potential dictates water movement from higher potential to lower potential, making the first statement incorrect. Matric potential represents the cohesive and adhesive forces binding water to solid surfaces, which always reduces free energy and results in negative values rather than positive ones. Thus, both statements

(A) Soil (-100.0 MPa) → Root (-1.5 MPa) → Leaf (-0.5 MPa) → Atmosphere (-0.1 MPa)
(B) Soil (-0.5 MPa) → Root (-0.1 MPa) → Leaf (-1.5 MPa) → Atmosphere (-50.0 MPa)
(C) Soil (-1.5 MPa) → Root (-1.5 MPa) → Leaf (-1.5 MPa) → Atmosphere (-1.5 MPa)
(D) Soil (-0.1 MPa) → Root (-0.5 MPa) → Leaf (-1.5 MPa) → Atmosphere (-100.0 MPa)

2016

199. Guttation occurs under conditions where:
(A) Transpiration rates are extremely high and soil moisture levels are low.
(B) Transpiration is low and soil moisture is abundant.
(C) The Casparian strip is heavily suberized.
(D) Stomata are fully open under midday sun.

2008

200. In addition to regulating water vapor loss, stomatal closure under drought stress directly restricts the entry of:
(A) Oxygen gas required for photorespiration.
(B) Gaseous nitrogen required for protein synthesis.
(C) Carbon dioxide for the Calvin-Benson cycle.
(D) Potassium ions required for cellular osmoregulation.

2017

201. Which of the following describes the concept of "water use efficiency" (WUE) at the whole-plant level?
(A) Total moles of CO_2 assimilated per unit time.
(B) Total water transpired divided by total root area.
(C) Total volume of water held within the plant tissues at maturity.
(D) Total biomass produced per unit of water transpired.

2016

202. Which specific signaling molecule is rapidly synthesized in roots in drying soil and transported via the xylem to shoots to initiate stomatal closure before leaf water status drops significantly?
(A) Abscisic acid
(B) Auxin
(C) Cytokinin
(D) Gibberellic acid

2023

203. Leaf senescence induced by drought is considered an adaptation primarily because it:
(A) Significantly increases the root-to-shoot ratio by increasing root mass.
(B) Reduces canopy transpiration surface, preventing lethal dehydration.
(C) Completely reverses the upward capillary flow of xylem sap.
(D) Directly enhances the photosynthetic rate of the remaining green leaves.

2012

204. Proline accumulation during drought stress is achieved through both increased biosynthesis and:
(A) Highly increased degradation by the activation of proline dehydrogenase (PDH).
(B) Decreased degradation by inhibition of proline dehydrogenase (PDH).
(C) Active transport out of the cell into the apoplast.
(D) Polymerization of proline into structural proteins.

2021

205. The rate-limiting enzyme in the biosynthesis of proline from glutamate in plants under stress is:
(A) Proline dehydrogenase (PDH)
(B) Pyrroline-5-carboxylate synthetase (P5CS)
(C) Glutamate dehydrogenase (GDH)
(D) Ornithine aminotransferase (OAT)

2004

206. Which of the following physiological processes is generally least sensitive to mild water deficit?
(A) Leaf expansion (cell growth)
(B) Stomatal conductance
(C) Respiration
(D) Photosynthetic electron transport

2015

207. An increase in the synthesis of cuticular wax under drought stress is a classic example of:
(A) Drought escape
(B) Osmotic adjustment
(C) Cavitation recovery
(D) Drought avoidance

2023

208. The accumulation of reactive oxygen species (ROS) during severe drought can cause extensive cellular damage, a process known broadly as:
(A) Severe osmotic stress
(B) Hypoxic stress
(C) Oxidative stress
(D) Thermotolerance

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(D) I, III, IV and V

2003

189. Proline is a multi-functional molecule during stress. Aside from acting as a compatible osmolyte, it also functions to:
(A) Stabilize structures, scavenge ROS, and buffer redox.
(B) Direct the enzymatic cleavage of specific stress-related mRNA transcripts.
(C) Act as a primary structural monomer for cellular lignin biosynthesis.
(D) Block plasmodesmatal connections to isolate dying adjacent cells.

2009

190. Which physiological parameter integrates both carbon assimilation and water loss, making it a critical trait for phenotyping drought tolerance in breeding programs?
(A) Relative water content (RWC)
(B) Leaf area index (LAI)
(C) Water use efficiency (WUE)
(D) Cell membrane stability (CMS)

2009

191. The stable carbon isotope ${}^{\{13\}}C$ is discriminated against by the enzyme Rubisco. Plants with lower stomatal conductance (e.g., during drought) will typically show:
(A) More discrimination against ${}^{\{13\}}C$, resulting in a lower $\frac{{}^{13}C}{{}^{12}C}$ ratio in their tissues.
(B) No change in the $\frac{{}^{13}C}{{}^{12}C}$ ratio, as Rubisco is unaffected by CO_2 supply.
(C) Complete exclusion of ${}^{\{12\}}C$.
(D) Less discrimination against ${}^{\{13\}}C$, yielding a higher tissue ratio.

2010

192. Which laboratory assay provides a direct measurement of the physical integrity of the plasma membrane following a period of desiccation or heat stress?
(A) Proline quantification assay
(B) Chlorophyll fluorescence $(\frac{F_v}{F_m})$
(C) Electrolyte leakage assay
(D) Carbon isotope discrimination analysis

2012

193. A crop variety is classified as "drought tolerant" based on agronomic standards if it:
(A) Completely ceases all stomatal transpiration upon initial soil drying.
(B) Maintains stable, high economic yield under limited water.
(C) Possesses the shortest overall life cycle among all tested varieties.
(D) Exhibits severe leaf senescence during mild stress to conserve water.

2014

194. Which of the following is considered an active mechanism of drought adaptation rather than a passive response to damage?
(A) Lipid peroxidation in chloroplasts.
(B) Rapid loss of leaf turgor leading to wilting.
(C) Cavitation of large xylem vessels.
(D) Synthesis and accumulation of dehydrins.

2017

195. In the context of water potential, why does the addition of solutes make the solute potential (Ψ_s) more negative?
(A) Solutes bind water, reducing its free energy and activity.
(B) Solutes physically block the movement of water molecules.
(C) Solutes increase the specific heat capacity of the solution.
(D) Solutes generate a positive hydrostatic pressure that counteracts tension.

2002

196. The matric potential (Ψ_m) is critically important in which of the following scenarios?
(A) Water movement through a large, water-filled xylem vessel in the stem.
(B) Water flow through the large central vacuole of a mesophyll cell.
(C) Water retention in very dry soil or within dry seeds.
(D) Transpirational loss of water vapor from the leaf.

2013

197. The principal function of aquaporins is to:
(A) Enhance membrane hydraulic conductivity for passive water flow.
(B) Facilitate the active transport of specific ions across the tonoplast.
(C) Increase the structural rigidity of the plasma membrane under stress.
(D) Stimulate the active pumping of protons to maintain membrane potential.

NODIA

2013

198. Select the correct sequence of water potential gradient values (Ψ_w) in the Soil-Plant-Atmosphere Continuum that would allow active transpiration to occur:

ANSWERS

1. (B) The heat energy required to raise the temperature of one gram of water by one degree Celsius.
Specific heat capacity represents the thermal energy needed to change the temperature of a substance. For water, this value is exceptionally high due to hydrogen bonding. This property allows plants to absorb substantial heat from their surroundings without experiencing large, rapid fluctuations in internal temperature, thereby maintaining metabolic stability and protecting cellular structures from heat stress.

2. (D) It allows for cooling of leaves during active transpiration.
Latent heat of vaporization is the energy required to transform liquid water into vapor. Because water has a high latent heat of vaporization, evaporating water from leaf surfaces absorbs a substantial amount of heat energy. This process effectively cools the plant canopy, preventing thermal damage to enzymes and maintaining optimal physiological conditions during high temperature stress.

3. (A) The cohesive forces between water molecules are primarily driven by covalent bonding.
Cohesive forces within liquid water represent the mutual attraction between water molecules. These forces are primarily driven by intermolecular hydrogen bonding rather than intramolecular covalent bonds. Hydrogen bonds form because water is a highly polar molecule, with unequal sharing of electrons creating partial charges that allow strong electrostatic interactions to continuously link neighboring molecules together.

4. (C) Adhesion
Adhesion refers to the attractive force operating between unlike molecules, such as water and the hydrophilic surfaces of tracheary elements or soil particles. Along with cohesion, adhesion is vital for capillary action, enabling water to climb xylem vessels and maintain a continuous column against gravity, which is essential for the upward transport of water in plants.

5. (C) A is true but R is false.
Water acts as an excellent temperature buffer in plant tissues because it possesses a remarkably high specific heat capacity, not a low one. This high specific heat capacity requires a significant amount of heat energy to alter water temperature, which helps prevent rapid thermal fluctuations in cells, ensuring that metabolic and physiological processes remain stable under changing environmental conditions.

NODIA

6. (D) Plasmolysis due to the exosmosis of water from the vacuole.
Placing a plant cell in a hypertonic solution causes water to move out of the cell down its water potential gradient. This process of exosmosis reduces turgor pressure, leading to the shrinkage of the protoplast away from the rigid cell wall. This physiological state of cellular shrinkage is known as plasmolysis and can lead to cell death.

7. (B) Imbibition
Imbibition is a special type of passive diffusion where dry hydrophilic solid colloids, such as proteins and cellulose in seeds, absorb water. This physical process occurs independently of osmotic potential and generates immense swelling pressure, which is essential for breaking the seed coat and initiating the metabolic processes required for subsequent germination and seedling establishment.

8. (B) I and III
Diffusion is a passive movement of substances along a concentration gradient. Imbibition is a specific passive absorption process that requires a strong physical affinity between the solid adsorbent and the imbibed liquid. Conversely, osmosis specifically involves the movement of solvent molecules, typically water, rather than solute particles, across a selectively or semi-permeable membrane.

9. (D) The loss of water vapor from leaves to the atmosphere.
Diffusion is the net movement of molecules from a region of higher concentration to one of lower concentration. During transpiration, water

2024
170. Which of the following instruments provides an integrated, non-destructive assessment of the whole-plant water status and transpiration efficiency in the field?
(A) Infrared thermometer
(B) Pressurized gas chamber
(C) Osmometer
(D) Spectrophotometer

2012
171. If a crop canopy has a temperature of 32°C and the ambient air temperature is 30°C, the CTD (Canopy Temperature Depression) is:
(A) +2°C
(B) -2°C
(C) 0°C
(D) +62°C

2015
172. A negative CTD value implies that the canopy is warmer than the ambient air. Physiologically, this indicates that the crop is likely:
(A) Actively transpiring and remaining well-hydrated.
(B) Experiencing water deficit with closed stomata.
(C) Exhibiting very high rates of photosynthesis.
(D) Undergoing rapid vegetative expansion.

2023
173. Soil moisture depletion limits crop growth by primarily causing:
(A) A decrease in soil matric potential making extraction difficult.
(B) A substantial increase in soil matric potential, making water easier to extract.
(C) An immediate cellular breakdown of the Casparian strip barrier.
(D) An excessive over-accumulation of water in the root cortical cells.

2012
174. Which physical parameter describes the ease with which water can move through the plant vascular system?
(A) Leaf area index (LAI)
(B) Diffusion pressure deficit (DPD)
(C) Plant hydraulic conductance
(D) Stomatal resistance

2005
175. Match the physiological response in List I with its primary mechanism or cause in List II.
List I: (Physiological response)
P. Leaf rolling
Q. Stomatal closure
R. Osmotic adjustment
S. Increased root-to-shoot ratio
List II: (Primary mechanism or cause)
1. Accumulation of proline and sugars
2. ABA-induced efflux of potassium from guard cells
3. Loss of turgor in specialized bulliform cells
4. Differential sensitivity of organ growth to ABA and reduced carbon supply
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-1, R-2, S-4
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-2, R-1, S-4

2021
176. Which of the following morphological traits is considered an adaptive mechanism to reduce the radiation load on a leaf during severe drought?
(A) Increased leaf thickness
(B) Increased stomatal density
(C) Dense leaf pubescence
(D) Enhanced chlorophyll synthesis

2012
177. The reduction of carbon assimilation during moderate drought stress is primarily attributed to:
(A) Irreversible damage to Photosystem II.
(B) Stomatal limitation of CO_2.
(C) Complete degradation of Rubisco.
(D) Depletion of soil nitrogen.

2001
178. Select the correct combination of statements regarding biochemical responses to water deficit:
I. Drought stress induces an imbalance between light energy absorbed and energy utilized in carbon fixation.
II. This imbalance leads to the formation of Reactive Oxygen Species (ROS).
III. ROS cause damage strictly to nucleic acids, sparing lipids and proteins.
IV. The ascorbate-glutathione cycle is a major enzymatic mechanism for detoxifying ROS.
Which of the above statements are correct?
(A) I, II and III
(B) II, III and IV
(C) I and IV
(D) I, II and IV

2003
179. The over-reduction of the photosynthetic electron transport chain under drought conditions frequently results in the transfer of an electron

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are incorrect descriptions of standard water potential dynamics in plants.

19. (A) From cell A to cell B
Water moves spontaneously along a thermodynamic gradient from areas of higher water potential to areas of lower water potential. Since a value of negative zero point eight Megapascals is greater than negative one point two Megapascals, cell A has a higher water potential than cell B, driving the net physical movement of water from cell A to cell B.

20. (C) Decreasing its free energy and lowering the water potential.
Introducing solute molecules into pure water disrupts the orderly arrangement of water molecules, thereby reducing their kinetic energy and overall thermodynamic freedom. This decrease in free energy directly lowers the overall water potential of the solution. Consequently, solute potential is always represented as a negative value, which reduces the total water potential of plant cells.

21. (A) Matric potential
Matric potential represents the component of water potential that is determined by the strong adsorptive forces between water molecules and solid surfaces, such as clay particles or cell walls. In dry or clay-rich soils, these physical interactions are extremely powerful, significantly reducing the free energy of water and making matric potential the primary factor retaining water against root uptake.

22. (A) III → IV → I → II
Water movement through the soil-plant-atmosphere continuum occurs along a continuous, decreasing gradient of water potential. Soil solution has the highest water potential, followed by root xylem, then leaf mesophyll cells, and finally the dry atmospheric air, which possesses the lowest water potential. This thermodynamic gradient is the primary force driving the passive transport of water through plants.

23. (B) It increases by only 0.01 MPa per meter of height.
Gravity potential represents the influence of elevation on the free energy of water. It increases by approximately zero point zero one Megapascals per meter of vertical height. In short herbaceous plants, this physical effect is minimal and contributes negligibly to total water potential calculations, though it becomes highly significant when assessing water transport in tall forest trees.

24. (C) It lowers the water potential due to dissolved solutes.
Osmotic potential, also known as solute potential, measures the effect of dissolved solutes on water potential. Solutes restrict the movement of water molecules, reducing their free energy. Therefore, osmotic potential always has a negative value, and its primary physiological role is to decrease the overall water potential of the cell, facilitating the inward osmotic movement of water.

25. (D) Gravity potential — Ψ_w
Water potential terminology uses distinct Greek symbols to represent individual components. While solute, pressure, and matric potentials are designated by specific subscripts, gravity potential is represented by the symbol psi with a subscript g. The symbol psi with a subscript w is used to represent the total water potential of the system rather than the gravity component.

26. (A) Plasmolyzed mesophyll cells
In living, turgid plant cells, pressure potential is positive due to the outward hydrostatic force of the protoplast against the cell wall. However, during severe plasmolysis, the protoplast shrinks and pulls completely away from the cell wall. At this point, turgor pressure drops to zero, and in some cases, can become slightly negative due to wall tension.

27. (B) Providing a low-resistance protein channel for passive diffusion of water.
Aquaporins are specialized transmembrane proteins that form selective channels across biological membranes. They facilitate the rapid, passive movement of water molecules down a thermodynamic water potential gradient. By significantly lowering the activation energy for water transport, these channels allow cells to adjust their volume and osmotic balance much faster than simple lipid bilayer diffusion allows.

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28. (B) I, II, IV and V
Aquaporins belong to the major intrinsic protein family and can be regulated by cytosolic pH, calcium, and phosphorylation. They selectively exclude protons to maintain cellular membrane potential. While some are plasma membrane

xylem. Guttation provides clear, visible proof that roots can actively generate hydrostatic pressure to move water upward in the absence of transpirational pull.

48. (C) Hydathodes
Guttation occurs through specialized structures located along the margins and tips of leaves, known as hydathodes. Hydathodes consist of open pores connected to a region of loosely arranged parenchyma cells called epithem, which are directly associated with the terminal ends of leaf vein xylem, allowing root pressure to force liquid water directly out of the plant.

49. (B) Lignification of the secondary cell walls.
The cohesion-tension mechanism subjects xylem conduits to extreme negative pressures, which can cause the vessels to collapse. To withstand this physical tension, the secondary cell walls of mature vessel elements and tracheids undergo extensive lignification. Lignin is a tough polymer that provides the necessary structural rigidity to prevent collapse during active daytime transpiration.

50. (D) Negative (under tension)
During active daytime transpiration, evaporation of water from leaf mesophyll cell walls pulls the remaining water column upward. This pull subjects the xylem sap to high physical tension, resulting in a negative pressure potential. This negative pressure is a key requirement of the cohesion-tension mechanism, allowing passive water transport to occur across great heights.

51. (A) Water evaporation from mesophyll cell walls into the substomatal cavity.
The primary pulling force for the ascent of sap is generated by the evaporation of water from the wet cell walls of mesophyll cells into the dry air spaces of the substomatal cavity. This localized loss of water increases surface tension at the air-water interface, creating a highly negative water potential that pulls water from the leaf xylem.

52. (C) They regulate stomatal aperture to balance CO_2 uptake and water loss.
Guard cells are specialized epidermal cells that flank each stomatal pore. Their primary physiological function is to control the size of the stomatal aperture. By opening and closing in response to environmental cues, they balance the uptake of carbon dioxide for photosynthesis with the loss of water vapor through transpiration, maximizing water use efficiency.

53. (A) Potassium (K^+)
Stomatal opening in response to light is driven by the active accumulation of potassium ions in guard cell vacuoles. This active uptake is initiated by light-activated proton pumps, which hyperpolarize the plasma membrane. The accumulation of potassium ions lowers the osmotic potential of the guard cells, driving water entry, increasing turgor pressure, and causing the pore to open.

54. (D) Malate
During the massive influx of potassium ions into guard cells, electrical neutrality must be maintained. This is achieved by accumulating counter-ions. Malate is synthesized within the guard cells through starch degradation and acts as a organic counter-anion. Chloride ions are also imported from surrounding cells to help balance the positive charges of accumulated potassium.

55. (A) P-2, Q-4, R-3, S-1
The pressure chamber directly measures leaf water potential by applying pressure to balance internal tension. Thermocouple psychrometers measure water potential by evaluating relative humidity and vapor pressure. Osmometers determine the solute or osmotic potential of extracted cellular sap. Finally, infrared thermometers monitor canopy temperature, which serves as a remote indicator of crop water status and transpiration.

56. (C) Stomatal resistance decreases under severe water deficit.
Stomatal resistance represents the physiological barrier to water vapor diffusion out of the leaf. Under severe water deficit, plants synthesize abscisic acid, which triggers guard cells to lose turgor and close the stomatal pore. This closing of the stomata increases stomatal resistance, rather than decreasing it, in order to prevent further dehydrative water loss.

57. (D) Apply gas pressure to a leaf until sap appears, balancing tension.
The Scholander pressure chamber technique operates on the principle of balancing forces. Xylem sap in a transpiring plant is under negative pressure. By placing a cut leaf inside a sealed chamber with the petiole protruding,

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severely reducing active, osmotic-driven root water absorption.

38. (D) Apoplastic, Symplastic, Transmembrane
Water absorbed by roots moves radially across the cortex to the vascular cylinder via three distinct pathways. The apoplastic pathway occurs through the non-living cell walls. The symplastic pathway proceeds through the living cytoplasm connected by plasmodesmata. The transmembrane pathway involves water repeatedly crossing plasma membranes. These pathways operate concurrently to facilitate radial water transport.

39. (B) Casparian strip
The apoplastic movement of water and solutes through the non-living cell wall space is blocked at the root endodermis by the Casparian strip. This specialized ring-like barrier forces all water and dissolved minerals to cross the selective plasma membrane of the endodermal cells, transition into the symplast, and undergo metabolic filtration before entering the xylem.

40. (C) Suberin
The Casparian strip is structurally characterized by the deposition of suberin, a complex hydrophobic biopolymer, within the radial and transverse walls of endodermal cells. Suberin acts as an impermeable physical barrier to water and dissolved solutes, effectively sealing the apoplast and preventing unregulated mass flow of substances between the root cortex and the vascular cylinder.

41. (D) Both (A) and (B) are correct.
Blocking the apoplast at the endodermis forces water and solutes to cross selective plasma membranes, allowing the plant to regulate ion uptake. It also creates a physical barrier that prevents the backflow of water and accumulated solutes from the vascular cylinder into the cortex, maintaining the positive hydrostatic pressure necessary for root pressure and guttation.

42. (A) Plasmodesmata
In the symplastic pathway, water and dissolved nutrients move through the continuous network of living cytoplasm in plant tissues. This movement occurs across adjacent cell walls through specialized cytoplasmic bridges called plasmodesmata. This intracellular route allows for regulated transport and selective assimilation of ions as they move from the root epidermis toward the central vascular tissue.

43. (B) Transmembrane route
The transmembrane route of radial water transport requires water molecules to cross the plasma membrane of each cell along the pathway twice, first during entry and again during exit. This pathway is highly regulated by the abundance and activity of aquaporin channel proteins, which control membrane permeability and determine the overall hydraulic conductivity of the root tissue.

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44. (B) Extensive hydrogen bonding among water molecules (cohesion).
Under the cohesion-tension theory, the continuous upward movement of water in the xylem is maintained by high tensile strength. This tensile strength is primarily provided by extensive hydrogen bonding between adjacent water molecules, known as cohesion. This strong mutual attraction prevents the water column from breaking under the immense negative pressure generated by leaf transpiration.

45. (A) Both A and R are true and R is the correct explanation of A.
High negative pressure within the xylem vessels during active transpiration can cause dissolved air to come out of solution, forming rapidly expanding bubbles. This physical process is called cavitation, and the resulting air embolisms block the transport of water. Thus, the physical tension directly explains how and why cavitation and vascular blockages occur.

46. (C) Pit membranes with tiny pores that block air bubbles.
Embolisms are prevented from spreading between adjacent xylem vessels by the structure of the shared pit membranes. These membranes act as micro-filters, possessing microscopic pores that allow liquid water to pass through easily while preventing the passage of expanding gas bubbles due to surface tension, thereby localizing the vascular blockage to a single vessel element.

47. (D) Guttation
Guttation is the exudation of liquid droplets from leaf margins, occurring under conditions of high soil moisture and low atmospheric transpiration. This phenomenon is driven by positive root pressure, which pushes water up through the

intrinsic proteins, others are highly abundant in the tonoplast membrane, meaning they are not restricted solely to the outer plasma membrane of plant cells.

29. (A) Dephosphorylation and cytosolic acidification.
Under drought or environmental stress, plants regulate water conservation by gating aquaporins. This structural closure is frequently triggered by dephosphorylation of specific conserved serine residues and a decrease in cytosolic pH. This cellular mechanism decreases the hydraulic conductivity of the root system, preventing unnecessary water loss and helping the plant maintain internal turgor during periods of water deficit.

30. (C) Vacuolar membrane
Tonoplast Intrinsic Proteins represent a major subclass of the aquaporin superfamily. They are localized in the tonoplast, which is the selective membrane enclosing the central vacuole of plant cells. These specialized channel proteins facilitate the rapid exchange of water between the cytoplasm and the vacuolar lumen, maintaining osmotic equilibrium and cellular turgor under fluctuating environmental conditions.

31. (D) Closure of aquaporins due to cytosolic acidification.
Soil flooding causes hypoxia, which shifts root metabolism from aerobic respiration to fermentation. This metabolic shift leads to lactic acid accumulation and cytosolic acidification. The drop in intracellular pH triggers the dephosphorylation and closure of root aquaporins, drastically increasing hydraulic resistance and reducing passive water uptake, which often causes flooded plants to wilt paradoxically.

32. (C) The water potential gradient between leaves and the atmosphere.
The primary driving force for the ascent of sap through the soil-plant-atmosphere continuum is the immense gradient in water potential between leaf tissues and the relatively dry surrounding atmosphere. This steep physical gradient drives transpiration, which pulls water from the xylem vessels, creating a continuous negative tension that is transmitted all the way down to the roots.

33. (B) Stomatal resistance at the leaf-atmosphere interface.
Within the soil-plant-atmosphere continuum, the pathway with the greatest resistance to water movement is the transition of water from a liquid phase inside the leaf to a gas phase in the atmosphere. This phase change is regulated by stomatal resistance, which acts as the primary physiological control mechanism to prevent excessive water loss under well-watered soil conditions.

34. (D) It decreases the vapor pressure deficit, thereby reducing the transpiration rate.
High atmospheric relative humidity increases the water vapor content of the air, which directly decreases the vapor pressure deficit between the leaf interior and the surrounding atmosphere. This smaller physical gradient reduces the driving force for evaporation, resulting in a significantly lower rate of transpiration, which helps conserve soil water during humid environmental conditions.

35. (A) Passive absorption is primarily driven by transpirational pull from the shoot.
Passive absorption is the dominant mechanism of water uptake in transpiring plants, driven by the tension created in the xylem by evaporation at the leaf level. This process does not require metabolic energy expenditure by root cells. Instead, the roots act as passive absorbing surfaces through which water is pulled along a continuous hydrostatic pressure gradient.

36. (C) Osmotic active absorption
Root pressure is generated when mineral ions are actively transported into the xylem of roots under conditions of low transpiration. This accumulation of solutes lowers the osmotic potential inside the xylem, driving water into the vascular cylinder. This osmotic process creates a positive hydrostatic pressure, which pushes water upward through the stem vessels.

37. (A) A cellular respiration inhibitor like cyanide
Active water absorption depends on the active transport of mineral ions into the root xylem, which creates the osmotic gradient necessary for water inflow. This ion transport requires metabolic energy in the form of ATP. Respiration inhibitors like cyanide halt ATP production, directly preventing active ion accumulation and

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gas pressure is applied until sap just returns to the cut surface. This applied pressure equals the original negative xylem tension.

58. (A) Wet-bulb depression in a chamber equilibrated with the tissue.
Thermocouple psychrometry measures water potential by placing a tissue sample in a small, sealed chamber. Once the vapor phase reaches thermodynamic equilibrium with the tissue, the relative humidity is determined by measuring the wet-bulb depression. This temperature depression is directly related to the vapor pressure of the water and is used to calculate water potential.

59. (B) Osmotic potential
Vapor pressure osmometry measures the dew point depression of an expressed sap sample to determine its total solute concentration. Because dissolved solutes reduce the vapor pressure of water, this measurement is directly related to the osmotic potential of the solution. This method is highly effective for quantifying solute concentration and analyzing osmotic adjustment in plants.

60. (B) Air temperature minus Canopy temperature
Canopy Temperature Depression is an index used to assess crop water stress and transpiration. It is calculated by subtracting the canopy temperature from the ambient air temperature. A positive value indicates that transpiration-induced evaporative cooling is keeping the canopy cooler than the surrounding air, which serves as an indicator of good plant water status.

61. (A) High transpiration and good crop water status.
A high, positive Canopy Temperature Depression value means the crop canopy is significantly cooler than the surrounding air. This cooling is caused by the evaporation of water during active transpiration. Therefore, a high value indicates that the stomata are open, water transport is occurring efficiently, and the plant has adequate access to soil moisture.

62. (C) Evaporative cooling resulting from transpirational water loss.
The physical link between canopy temperature and plant water status is evaporative cooling. As water transpires through open stomata, it absorbs latent heat from the leaf tissue to transition into vapor. This heat absorption lowers the temperature of the leaf surface, making canopy temperature a reliable indicator of stomatal conductance and overall crop water status.

63. (D) Thermal radiation emitted by the crop canopy.
Infrared thermometry measures canopy temperature by detecting the long-wave infrared thermal radiation emitted by the plant surfaces. The intensity of this emitted radiation is proportional to the surface temperature of the leaves. This non-destructive, remote sensing method allows researchers to monitor transpirational cooling and assess water stress levels across entire fields quickly.

64. (C) Water supply and atmospheric evaporative demand.
Crop water deficit occurs when the rate of transpiration exceeds the rate of root water absorption. This physiological imbalance is determined by the relationship between the available soil water supply and the atmospheric evaporative demand. When the soil cannot supply water fast enough to match atmospheric demand, the plant experiences water stress and loses turgor.

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65. (B) High soil moisture
Atmospheric evaporative demand is driven by environmental factors that increase the vapor pressure gradient between the leaf and the air. High temperatures, low relative humidity, and high wind speeds all increase this demand. Conversely, high soil moisture influences water supply to the roots but does not directly alter the evaporative demand of the surrounding atmosphere.

66. (D) Efficiency of liquid water movement through the plant.
Plant hydraulic conductance is a measure of the ease with which liquid water moves through the root, stem, and leaf pathways. It is calculated as the ratio of the water flow rate to the water potential gradient across the tissue. High hydraulic conductance ensures efficient water transport, supporting active transpiration and photosynthesis during the day.

67. (A) Xylem cavitation and embolism.
During progressive drought stress, high negative pressure in the xylem vessels can cause dissolved gases to form bubbles. This process of cavitation leads to air embolisms that block water flow. These vascular blockages decrease the overall hydraulic conductance of the plant, reducing water transport to the leaves and causing stomatal closure to prevent dehydration.

68. (C) Increased allocation of biomass to roots, raising root-to-shoot ratio.
In response to mild water deficit, plants alter their biomass allocation to favor root development. By directing more carbohydrates to the roots, the plant increases primary root elongation and branch development. This morphological adjustment raises the root-to-shoot ratio, allowing the plant to explore deeper soil layers for water while reducing the transpirational shoot surface area.

69. (A) Reducing leaf area exposed to solar radiation to limit transpiration.
Leaf rolling is an adaptive morphological response observed in many grass species during drought. By rolling the leaf blade, the plant reduces the effective surface area exposed directly to solar radiation. This physical change decreases leaf temperature and creates a humid microenvironment inside the rolled leaf, lowering the vapor pressure deficit and reducing transpirational water loss.

70. (D) Reducing transpirational surface area to conserve water for meristems.
Severe drought triggers leaf senescence and abscission, particularly in older leaves. While this reduces the overall carbon assimilation rate, it benefits the plant by decreasing the total transpirational surface area. This morphological response conserves the remaining soil water, allowing the plant to maintain the viability of critical apical meristems and reproductive organs during prolonged dry spells.

71. (B) Differential sensitivity of root and shoot growth to ABA.
The adjustment of root-shoot allometry under drought stress is regulated by abscisic acid. Root and shoot tissues display different sensitivities to this phytohormone. Under water deficit, accumulated abscisic acid restricts shoot growth to prevent water loss, while continuing to support primary root elongation, which allows the root system to grow deeper into the soil profile.

72. (C) Stomatal closure
Stomatal closure is widely considered the earliest physiological response of plants to water deficit. When soil water availability decreases, the reduction in root turgor triggers rapid chemical signaling, including the synthesis and transport of abscisic acid. This signaling causes guard cells to lose turgor and close the stomatal pore, conserving water before major tissue dehydration occurs.

73. (D) Intercellular CO_2 concentration and carbon assimilation.
Although stomatal closure is an important mechanism for conserving water, it restricts the diffusion of carbon dioxide into the leaf interior. This restriction decreases the intercellular carbon dioxide concentration, which directly limits the rate of photosynthesis and carbon assimilation, leading to reduced plant growth and biomass accumulation under prolonged drought conditions.

74. (A) It impairs transport due to decreased turgor in sieve elements.
Phloem transport relies on pressure-driven mass flow, which is generated by high turgor pressure in sieve tube elements. Under severe water deficit, the reduction in overall plant water potential decreases the turgor of the phloem system. This change impairs the mass flow of photoassimilates from source leaves to sink tissues, reducing overall nutrient distribution.

75. (B) Water deficit decreases the expression of antioxidant enzymes.
Drought stress triggers the accumulation of reactive oxygen species in plant cells, which can cause lipid peroxidation and membrane damage. To counter this oxidative stress, plants increase the expression and activity of antioxidant enzymes like superoxide dismutase and catalase. Abscisic acid plays a major role in coordinating this biochemical defense system during water deficits.

76. (B) Carbon dioxide
Reactive oxygen species are highly reactive molecules derived from diatomic oxygen. They are generated as normal byproducts of cellular metabolism and accumulate under environmental

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stress. Common examples include superoxide anions, hydrogen peroxide, and hydroxyl radicals. Carbon dioxide is a stable, non-reactive molecule used in carbon fixation and is not classified as a reactive oxygen species.

77. (A) Abscisic acid (ABA)
Abscisic acid is the primary phytohormone that coordinates plant responses to abiotic stress, particularly water deficit. It is synthesized in both roots and leaves during drought, acting as a systemic signal that induces stomatal closure in guard cells and regulates the expression of numerous stress-responsive genes involved in cellular protection and osmotic adjustment.

78. (C) Type 2C protein phosphatases (PP2Cs)
In the core abscisic acid signaling pathway, the binding of the hormone to its receptor forms a complex that directly binds and inhibits type 2C protein phosphatases. In the absence of phosphatase inhibition, these enzymes keep downstream kinases inactive. Their inhibition allows SnRK2 kinases to become activated, phosphorylating ion channels to trigger stomatal closure.

79. (D) Drought escape
Drought escape is an adaptive phenological strategy where a plant completes its entire life cycle, from seed germination to seed production, before the onset of a dry season. This rapid development allows the plant to avoid experiencing tissue water deficit, survival being ensured by desiccation-tolerant seeds that remain dormant in the soil until the next rainy season.

80. (C) Drought escape
Desert ephemerals are classic examples of plants that utilize the drought escape strategy. These plants are characterized by extremely short lifespans. Following rainfall, they germinate, grow, flower, and set seed rapidly, completing their life cycle within a few weeks. This fast-paced development allows them to avoid the severe dry periods characteristic of arid environments.

81. (B) Maintain water potential despite environmental water shortage.
Drought avoidance is the ability of a plant to maintain relatively high tissue water potential and turgor despite dry soil and air conditions. This is achieved through mechanisms that either maximize root water absorption, such as deep root systems, or minimize water loss, such as thick cuticular waxes and rapid stomatal closure.

82. (D) Development of a deep and extensive root system.
The development of a deep and extensive root system is a classic morphological mechanism of drought avoidance. This adaptation allows the plant to access water stored in deeper, hydrated soil layers. By maintaining a steady water supply, the plant can keep its internal water potential high and continue transpirational cooling, avoiding cellular dehydration during dry periods.

83. (A) Reducing non-stomatal transpiration when stomata are closed.
Cuticular waxes form a hydrophobic barrier on the leaf epidermis. Under drought stress, after stomata have closed to restrict transpiration, water can still escape through the cuticle. Increased deposition of cuticular waxes reduces this non-stomatal water loss, helping the plant conserve internal moisture and maintain tissue turgor over long periods of water deficit.

84. (C) Accelerated transition to the reproductive stage.
Altered phenology under drought stress often manifests as an accelerated transition from vegetative growth to the reproductive stage. This response is driven by stress-induced signaling pathways that promote early flowering and seed development, ensuring that the plant reproduces and secures the next generation before soil moisture is completely depleted by the ongoing dry period.

85. (A) Both A and R are true and R is the correct explanation of A.
Deep-rooted crops display superior drought avoidance compared to shallow-rooted species because their root systems can access moisture from deeper soil layers that remain hydrated. This structural advantage allows them to absorb water and maintain high internal water potential even when the surface soil is completely dry, directly explaining their ability to avoid water stress.

86. (D) Endure low water potential and cellular dehydration.
Drought tolerance is the ability of a plant to survive and function while its internal tissues

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undergo severe dehydration and low water potential. This strategy relies on cellular-level adaptations, such as the accumulation of compatible solutes and protective proteins, which maintain cell membrane stability and prevent macromolecular damage when water content is extremely low.

87. (B) Active net accumulation of compatible solutes.
Osmotic adjustment is a cellular mechanism of drought tolerance achieved through the active accumulation of compatible solutes within the cytoplasm. This accumulation lowers the osmotic potential of the cell, driving water entry and helping to maintain turgor pressure at lower water potentials, allowing for continued cell expansion and stomatal function during periods of moderate water stress.

88. (C) II
Compatible solutes, also known as osmolytes, are organic compounds that accumulate in the cytoplasm during osmotic adjustment. Unlike inorganic ions, these molecules do not interfere with normal enzymatic functions even at high concentrations. Instead, they act as protective chaperones, stabilizing proteins and cell membranes against dehydration damage, making the second statement incorrect.

89. (D) Lignin
Lignin is a structural polymer deposited in plant cell walls, providing rigidity and mechanical strength rather than participating in osmotic regulation. In contrast, proline, glycine betaine, and trehalose are compatible solutes that accumulate under osmotic stress, helping maintain cellular water balance, protect proteins, and stabilize membranes without disrupting normal metabolism.

90. (A) Maintain turgor and volume at lower water potential.
The primary physiological benefit of osmotic adjustment is that it enables cells to maintain turgor pressure and volume under conditions of low water potential. By lowering internal osmotic potential, the cell can still absorb water from drying soils, keeping the stomata open and allowing vital metabolic processes to continue despite environmental water deficits.

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91. (B) Δ^1-pyrroline-5-carboxylate synthetase (P5CS)
Proline accumulation during drought stress is a highly regulated process. The primary rate-limiting enzyme in proline biosynthesis is delta-1-pyrroline-5-carboxylate synthetase, which catalyzes the initial steps converting glutamate to proline. Under water deficit, the gene encoding this enzyme is significantly upregulated, leading to increased synthesis and accumulation of this protective osmolyte.

92. (B) Serve as chaperones to prevent protein aggregation.
Late Embryogenesis Abundant proteins are hydrophilic proteins that accumulate during seed maturation and vegetative water stress. Their primary function is to protect cellular structures from desiccation. They act as molecular chaperones, binding to other proteins to prevent aggregation and denaturation, and helping to maintain the stability of cell membranes under severe dehydration conditions.

93. (A) LEA proteins (Group II)
Dehydrins are a major group of Late Embryogenesis Abundant proteins, classified as Group Two. They are characterized by highly conserved lysine-rich domains and accumulate in vegetative tissues during drought, cold, and salinity stresses. These hydrophilic proteins act as stabilizers, protecting macromolecular structures and cell membranes from the damaging physical effects of dehydration.

94. (C) Superoxide dismutase (SOD)
Superoxide dismutase is a key antioxidant enzyme that acts as the first line of defense against oxidative stress. It catalyzes the dismutation of highly reactive superoxide radicals into hydrogen peroxide and molecular oxygen. This activity prevents the formation of even more damaging hydroxyl radicals, protecting cellular components from lipid peroxidation and oxidative degradation during drought.

95. (A) P-4, Q-1, R-3, S-2
Superoxide dismutase converts superoxide into hydrogen peroxide. Catalase breaks down hydrogen peroxide in peroxisomes. Ascorbate peroxidase uses ascorbate as an electron donor to reduce hydrogen peroxide in chloroplasts. Finally, glutathione reductase maintains the cellular redox state by reducing oxidized glutathione,

representing a highly coordinated enzymatic defense system that scavenges reactive oxygen species under stress.

96. (C) Ascorbic acid
Ascorbic acid, also known as vitamin C, is a key non-enzymatic antioxidant in plants. It acts as an electron donor in the ascorbate-glutathione cycle, helping ascorbate peroxidase detoxify hydrogen peroxide. It also directly scavenges singlet oxygen and superoxide radicals, protecting the photosynthetic apparatus and cell membranes from oxidative damage during drought stress.

97. (B) CO_2 assimilation rate to transpiration rate.
At the single-leaf level, water use efficiency is defined as the ratio of the net carbon dioxide assimilation rate to the transpiration rate. This ratio measures the amount of carbon fixed per unit of water lost through the stomata. It is an important trait for identifying crop varieties that maintain productivity under limited water conditions.

98. (A) I and II
Rubisco discriminates against carbon thirteen in favor of carbon twelve. During drought, stomatal closure limits carbon dioxide entry, reducing the discrimination because the enzyme is forced to fix more of the available carbon thirteen. Therefore, plants with higher long-term water use efficiency, which maintain lower stomatal conductance, display lower carbon isotope discrimination values.

99. (A) $\left[\frac{\text{Fresh Weight} - \text{Dry Weight}}{\text{Turgid Weight} - \text{Dry Weight}}\right] \times 100$
Relative water content is a standard physiological index used to evaluate plant water status. It is calculated by subtracting dry weight from fresh weight, and dividing that value by the difference between turgid weight and dry weight, multiplied by one hundred. This measurement reflects the current water content relative to the maximum water capacity of the tissue.

100. (C) High Cell Membrane Stability (CMS)
A plant with high cellular drought tolerance can withstand desiccation without experiencing structural damage. A key indicator of this capacity is high cell membrane stability, which reflects the ability to maintain the structural and functional integrity of the plasma membrane. This integrity prevents the leakage of intracellular solutes under conditions of severe water deficit.

101. (A) Electrolyte leakage from stressed leaf tissue.
The cell membrane stability test is a standard method used to screen germplasm for drought tolerance. It operates by measuring the leakage of electrolytes from stressed leaf tissues into a surrounding aqueous medium. When cell membranes are damaged by dehydration, their permeability increases, allowing ions to leak out and raising the electrical conductivity of the solution.

102. (D) Greater membrane damage.
In the cell membrane stability test, a higher electrical conductivity in the bathing solution indicates a greater amount of electrolyte leakage from the leaf tissue. This leakage is direct evidence of increased membrane permeability and structural damage caused by dehydration, indicating lower drought tolerance and a reduced capacity of the cells to maintain membrane integrity.

103. (B) Thermal Infrared (TIR) Imaging
Thermal infrared imaging is a non-destructive technology used in high-throughput phenotyping platforms. It detects the thermal radiation emitted by plant leaves, allowing researchers to monitor canopy temperature. Since canopy temperature is directly related to transpiration and stomatal conductance, this method is highly effective for screening plant water status across large populations.

104. (A) Hydraulic lift
Hydraulic lift, also known as hydraulic redistribution, is the passive movement of water through root systems from wet, deeper soil layers to drier, shallower soil profiles. This process occurs during the night when stomata are closed and transpirational pull is low, driven by the water potential gradient between the deep and shallow soil zones.

105. (D) The water vapor concentration gradient between leaf and air.
The rate of diffusion of water vapor out of a stoma is determined by the physical concentration gradient of water vapor between the humid leaf interior and the drier surrounding atmosphere. This gradient, known as the vapor pressure deficit, provides the primary physical driving force for evaporation, with higher gradients resulting in faster transpirational water loss.

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106. (A) The movement of a solvent across a differentially/selectively permeable membrane.
Osmosis is a specific type of diffusion that refers exclusively to the net movement of solvent molecules, typically water, from a region of higher water potential to one of lower water potential. This passive transport process occurs across a selectively or differentially permeable membrane, which restricts the passage of solutes while allowing solvent molecules to pass freely.

107. (B) Zero
Diffusion pressure deficit represents the water-absorbing capacity of a plant cell, calculated as the difference between osmotic pressure and turgor pressure. When a cell absorbs water and becomes fully turgid, its internal turgor pressure increases until it perfectly balances the osmotic pressure. At this equilibrium point, net water uptake stops, and the deficit reaches zero.

108. (B) I, II and IV
Water movement through the soil-plant-atmosphere continuum is passively driven by a continuous gradient of decreasing water potential from soil to atmosphere. Phase transitions from liquid water to vapor occur within the substomatal cavities of leaves before exiting. Conversely, resistance to water flow is highly variable across different organs, and atmospheric humidity significantly alters this potential gradient.

109. (A) Decrease in leaf stomatal conductance
Under mild soil water deficit, plants rapidly respond to minimize water loss before visible physical damage occurs. Stomatal closure, which directly decreases leaf stomatal conductance, is the most sensitive and immediate physiological indicator. This rapid response is regulated by chemical signals and prevents more severe consequences like leaf wilting or catastrophic xylem embolisms.

110. (C) Cytokinins
Stomatal movements are tightly regulated by complex hormonal interactions. While abscisic acid is the primary hormone promoting stomatal closure under stress, cytokinins act antagonistically to prevent closure and stimulate opening. Cytokinins modulate ion channels, promote potassium accumulation in guard cells, and decrease sensitivity to abscisic acid, thereby maintaining transpirational water flow and carbon dioxide assimilation.

111. (D) The active accumulation of ions in xylem sap that osmotically draws water.
Root pressure is a positive hydrostatic pressure generated in the xylem of some plants. This physiological phenomenon occurs when root cortical cells actively transport mineral ions into the vascular cylinder, lowering the solute potential of the xylem sap. This hypertonic environment drives the osmotic movement of water from the soil into the xylem, building upward physical pressure.

112. (C) Its extensive intermolecular hydrogen bonding.
The unusual thermal properties of water, such as its high specific heat capacity and high latent heat of vaporization, are directly caused by its extensive intermolecular hydrogen bonding. Each water molecule can form multiple hydrogen bonds with neighboring molecules. Breaking these strong cohesive bonds requires significant thermal energy, which stabilizes plant temperatures in changing environments.

113. (B) Mid-to-late afternoon
During a typical diurnal cycle under sunny conditions, leaf water potential reaches its minimum value during the mid-to-late afternoon. This timing corresponds to the period when solar radiation and air temperature are high, creating a peak in transpirational water loss. This high rate of transpiration temporarily exceeds root water absorption, resulting in maximum tension.

114. (D) Matric potential
The initial phase of water absorption by dry seeds is known as imbibition, which is a physical process that occurs without active metabolic energy. It is driven by a highly negative matric potential. The dry cell walls, proteins, and colloidal starches within the seed have a strong affinity for water, attracting and binding water molecules intensely.

115. (A) Enhanced transpiration due to decreased boundary resistance.
The boundary layer consists of a pocket of relatively still, humid air surrounding the leaf surface. Increased wind speed sweeps this layer away, reducing its thickness and significantly decreasing boundary layer resistance to water

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vapor diffusion. Consequently, the concentration gradient of water vapor between the leaf interior and the air steepens, which enhances the rate of transpiration.

116. (C) The rupture of the water column and its filling with air or vapor.
In the xylem vessels of transpiring plants, water is pulled upward under significant negative pressure or tension. Cavitation occurs when this extreme tension causes the continuous water column to break or rupture. This rupture allows air or water vapor to rapidly expand into the conduit, forming an embolism that blocks the physical pathway for upward water transport.

117. (A) Their narrower diameter and pit membranes which effectively isolate bubbles.
Tracheids are less vulnerable to catastrophic cavitation than large vessel elements due to their distinct anatomical characteristics. Their narrower lumen diameter provides greater structural support and limits bubble size, while their highly specialized, micro-porous pit membranes effectively prevent air bubbles from spreading into adjacent functional conduits. This design restricts xylem embolisms to a highly localized area.

118. (D) It is completely blocked by the Casparian strip in the endodermis.
The symplastic pathway is the interconnected network of cytoplasm linked by plasmodesmata, allowing water and small solutes to move between cells. Unlike the apoplastic pathway, which is blocked by the suberized Casparian strip in the root endodermis, the symplastic pathway remains unblocked and serves as the primary route through which water crosses the endodermal layer.

119. (B) Aquaporins
Water moving radially across root tissues can take the transmembrane pathway, which requires water molecules to cross plasma membranes repeatedly. Because lipid bilayers present a natural barrier to polar water molecules, this pathway relies heavily on the abundance, density, and open state of aquaporins. These specialized channel proteins facilitate rapid, passive water movement across cellular membranes.

120. (C) The vapor pressure deficit (VPD) of the surrounding air.
Atmospheric evaporative demand is primarily determined by the vapor pressure deficit of the surrounding air, which measures the difference between the actual moisture level and the maximum amount of moisture the air can hold at saturation. A higher deficit increases the rate of evaporation from the leaf surface into the drier ambient atmosphere.

121. (D) -0.8 MPa
The total water potential of a plant cell is mathematically defined as the sum of its solute potential and its pressure potential. Using the given values, adding the negative osmotic potential of negative one point five megapascals to the positive turgor pressure of zero point seven megapascals yields a final cellular water potential of negative zero point eight megapascals.

122. (A) The cell will lose water and its turgor pressure will decrease.
Water moves passively along a thermodynamic gradient from an area of higher water potential to an area of lower water potential. In this scenario, the cell has a water potential of negative zero point eight megapascals, which is higher than the surrounding apoplastic fluid water potential of negative one point zero megapascals, causing water loss and decreased turgor.

123. (B) Soil water is present but unavailable due to salinity or cold.
Physiological drought describes an environmental condition where water is physically present in the surrounding soil but cannot be absorbed by the plant roots. This situation typically arises due to low soil temperatures, which reduce root permeability, or high soil salinity, which decreases the osmotic potential of the soil solution below the water potential of root cells.

124. (B) Deeper roots sustaining transpiration.
Transpirational water loss cools leaves via latent heat of vaporization. Under soil drying conditions, a plant genotype that maintains a cooler canopy relative to others is actively transpiring. This sustained transpiration indicates the presence of a deeper, highly functional root system capable of extracting moisture from deeper soil layers that remain hydrated during drought.

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prevent the catastrophic spread of these bubbles from an affected vessel to adjacent functional conduits, plants rely on bordered pits or micro-porous pit membranes. These specialized structures act as mechanical valves, trapping bubbles while allowing water to pass through freely.

165. (A) Both A and R are true and R is the correct explanation of A.
Root pressure is a positive hydrostatic pressure that pushes water upward. However, it cannot solely account for the ascent of sap in tall trees like redwoods. This limitation exists because the maximum magnitude of root pressure typically does not exceed zero point five megapascals, which can only lift water a few meters high.

166. (D) Cuticular transpiration
While stomatal transpiration accounts for the vast majority of transpirational water loss in plants, a small portion of water vapor is lost directly through the outer protective layer of the leaf. This pathway, known as cuticular transpiration, occurs across the waxy cuticle of the epidermal layer and is largely independent of stomatal movements.

167. (B) Decrease transpiration rates by adding resistance.
The boundary layer is a zone of still, moist air surrounding the leaf surface. Under drought, an increase in boundary layer thickness acts as an additional physical barrier to water vapor diffusion, thereby increasing boundary layer resistance. This extra resistance reduces the rate of transpirational water loss, serving as a protective mechanism.

168. (B) II and III
Cellulose microfibrils in guard cells are radially oriented, which restricts expansion in width while allowing longitudinal expansion, causing the cells to bow outward. Additionally, stomatal opening is actively driven by the influx, rather than the efflux, of potassium ions. Therefore, both descriptions of mechanical restriction and ion transport direction are scientifically incorrect.

169. (D) Measuring the evaporative cooling effect in a sealed chamber.
Thermocouple psychrometry is a precise laboratory technique used to measure water potential in plant tissues or soil. It operates by sealing a sample in a chamber and measuring the relative humidity of the air space. By determining the dew point or evaporative cooling effect of water on a fine thermocouple, it calculates water potential.

170. (A) Infrared thermometer
An infrared thermometer is a valuable field instrument that provides non-destructive, integrated assessments of whole-plant water status. By measuring canopy temperature, it evaluates transpirational cooling under drought. It allows breeders to rapidly screen hundreds of genotypes in a short time, serving as a reliable indicator of stomatal conductance and water uptake capacity.

171. (B) -2°C
Canopy temperature depression is calculated as the ambient air temperature minus the canopy temperature. In this case, subtracting the crop canopy temperature of thirty-two degrees Celsius from the ambient air temperature of thirty degrees Celsius yields a value of negative two degrees Celsius, which represents a negative canopy temperature depression value.

172. (B) Experiencing water deficit with closed stomata.
A negative canopy temperature depression indicates that the crop canopy is warmer than the ambient air. Physiologically, this signifies that the plants have closed their stomata to prevent excessive water loss due to soil water deficit. This closure reduces transpirational cooling, causing solar radiation to heat the leaf tissues above the air temperature.

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173. (A) A decrease in soil matric potential making extraction difficult.
As soil moisture is depleted, the remaining water is held more tightly by capillary and adsorptive forces to the soil particles. This results in a sharp decrease in soil matric potential, which lowers the overall soil water potential. Consequently, the gradient between root and soil is reduced, making water extraction increasingly difficult.

174. (C) Plant hydraulic conductance
Plant hydraulic conductance is the physiological parameter that quantifies the ease with which liquid water moves through the vascular transport system. It is defined as the ratio of water flow rate to the water potential difference

135. (B) P-2, Q-3, R-1, S-4
Plant adaptations to water deficit are categorized into distinct strategies. Early flowering represents drought escape, enabling reproduction before water depletion. Deep roots avoid drought by enhancing water uptake, whereas increased cuticular wax represents avoidance via water conservation. Finally, osmotic adjustment represents true physiological tolerance, allowing cells to maintain turgor under dehydrated conditions.

136. (C) Assessing observable physical and physiological traits of the plant.
In drought physiology and crop breeding, phenotyping refers to the systematic assessment of observable physical, morphological, and physiological traits of a plant. This process involves evaluating characteristics such as leaf relative water content, canopy temperature, stomatal conductance, and root depth, allowing researchers to link genetic variation with actual performance under stress conditions.

137. (D) Canopy temperature measured by infrared thermometry.
Infrared thermometry is a powerful, non-destructive tool used to measure canopy temperature, serving as an indirect, high-throughput surrogate trait for plant water status. A cooler canopy under drought indicates sustained transpirational cooling, which directly reflects high stomatal conductance and the presence of a deep root system capable of continuous water uptake from deep soil.

138. (A) Mechanisms for drought avoidance.
Relative water content is a direct measure of plant tissue hydration. Maintaining a higher relative water content during severe drought, such as eighty percent compared to sixty percent, indicates that the plant has superior mechanisms for drought avoidance. These mechanisms, including deeper roots or tighter stomatal control, successfully prevent desiccation and maintain internal hydration.

139. (B) Antioxidant defense systems and protective osmolytes.
High cell membrane stability is a critical physiological indicator of drought tolerance. It is primarily attributed to robust antioxidant defense systems, which detoxify destructive reactive oxygen species, and the accumulation of protective compatible osmolytes. These osmolytes stabilize the lipid bilayer, prevent lipid peroxidation, and maintain the structural integrity of the plasma membrane during dehydration.

140. (B) Dehydroascorbate reductase
The ascorbate-glutathione cycle is a vital pathway for scavenging hydrogen peroxide in chloroplasts and other plant compartments. Within this specific metabolic cycle, dehydroascorbate reductase is a critical enzyme that catalyzes the reduction of dehydroascorbate to ascorbate using glutathione as the electron donor, thereby maintaining the pool of active antioxidants.

141. (A) A signaling molecule at low levels and a toxin at high levels.
Hydrogen peroxide plays a dual-natured role in plant physiological responses to environmental stress. At low concentrations, it functions as an essential secondary signaling molecule that regulates gene expression and triggers stress adaptation mechanisms, including stomatal closure. However, at high concentrations, it acts as a destructive toxin that causes oxidative damage to biomolecules.

142. (C) Xylem sap, primarily in the form of ABA.
When roots initially perceive drying soil, they synthesize chemical signals to communicate this stress to the shoots before shoot water status declines. This non-hydraulic signal is transported from the roots to the leaves via the xylem sap, primarily in the form of abscisic acid, which triggers rapid stomatal closure and limits water loss.

143. (D) Increase in the surrounding air relative humidity.
The rate of transpiration is driven by the water vapor concentration gradient between the leaf interior and the surrounding air. Increasing the relative humidity of the surrounding air reduces this concentration gradient, thereby decreasing the vapor pressure deficit. As a result, the physical driving force for evaporation is lowered, reducing the transpiration rate.

144. (C) Solar energy driving leaf evaporation.
According to the cohesion-tension theory, the passive movement of water from the soil through the plant to the atmosphere is driven by tension. This tension is generated by transpiration, which

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is evaporation of water from leaves. The ultimate energy source driving this continuous process is solar energy, which heats the leaves and powers evaporation.

145. (B) Placing the cell in a hypotonic solution (e.g., pure water).
Plasmolysis is the shrinking of the protoplast away from the cell wall when a plant cell is placed in a hypertonic solution. This process can be experimentally reversed by transferring the plasmolysed cell into a hypotonic solution, such as pure water. Water then moves down its potential gradient into the cell, restoring turgor.

146. (D) A lower (more negative) leaf water potential.
A pressure chamber is used to measure leaf water potential by applying external physical pressure to force xylem sap back to the cut surface of the petiole. A higher gauge pressure required to express the sap indicates that the water within the xylem is under greater tension, which corresponds to a more negative leaf water potential.

147. (A) Close to zero and generally ignored in calculations.
In fully hydrated, fleshy plant tissues, matric potential is generally close to zero and is typically ignored in water potential calculations. This is because the volume of free water in the vacuoles and cytoplasm is high, making the matric forces exerted by cell walls and macromolecules negligible compared to the dominant osmotic and turgor potentials.

148. (C) ABA binding to PYR/PYL $\rightarrow$ Inhibition of PP2C $\rightarrow$ Activation of SnRK2 $\rightarrow$ Activation of SLAC1
The core abscisic acid signaling cascade begins with hormone binding to PYR/PYL/RCAR receptors. This binding triggers the physical association and inhibition of PP2C phosphatases. Consequently, SnRK2 kinases are released from inhibition, auto-phosphorylate, and subsequently activate the slow anion channel SLAC1 on the guard cell membrane, driving turgor loss and stomatal closure.

149. (A) It buffers plants against rapid temperature fluctuations.
Water has a high specific heat capacity, meaning it must absorb or lose a large amount of heat energy to undergo a temperature change. Biologically, this property provides thermal stability, buffering plants against rapid external temperature fluctuations. It prevents critical metabolic enzymes from experiencing rapid heat inactivation during sunny days or freezing during cold nights.

150. (D) The 104.5-degree angle and oxygen's high electronegativity.
The dipolar nature of water is determined by its molecular geometry and atomic properties. Oxygen possesses a high electronegativity relative to hydrogen, creating an unequal sharing of electrons in the covalent bonds. Together with the asymmetrical, bent molecular structure of one hundred and four point five degrees, this asymmetry generates distinct partial positive and partial negative charges.

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151. (B) Matric potential
Imbibition is a passive physical process representing a special type of diffusion. It is driven by a steep gradient of matric potential between the dry, colloidal components of the seed and the surrounding water. This extremely negative matric potential attracts and binds water molecules tightly to surfaces, initiating seed swelling and metabolic reactivation.

152. (C) Breaking the seed coat during early germination.
The physical pressure generated during imbibition is extremely high and plays a critical ecological role. In natural environments, this enormous imbibition pressure is essential for breaking open the rigid protective seed coat during the initial stages of germination. This structural rupture allows the emerging radicle and plumule to escape and grow into the soil.

153. (D) Both (B) and (C) are correct definitions/ relations.
Osmotic pressure is defined as the maximum hydrostatic pressure that must be applied to a solution to prevent the inward flow of pure solvent across a semi-permeable membrane. Quantitatively, it is equivalent to the solute potential of that solution but possesses the opposite mathematical sign, representing a positive physical force.

154. (A) Cell expansion is inhibited long before photosynthesis declines.
Under progressive soil water stress, different physiological processes display varying levels of sensitivity. Physical cell expansion is highly sensitive and is inhibited at very mild water deficits, long before other primary processes like photosynthesis or respiration begin to decline. This early reduction in growth is driven directly by the loss of cellular turgor pressure.

155. (B) DPD is equal to Ψ_w but has an opposite sign.
Diffusion pressure deficit and water potential represent the same thermodynamic properties of water, describing the chemical potential of water in a system relative to pure water. Quantitatively, they are numerically equal to one another but possess opposite mathematical signs, where water potential is negative and diffusion pressure deficit is expressed as a positive value.

156. (B) Pressure potential cancels osmotic potential.
The water potential of a plant cell is determined by the sum of its negative osmotic potential and its positive pressure potential. In a fully turgid cell, water uptake has reached equilibrium because the outward wall pressure or positive turgor pressure has increased to perfectly equal and cancel out the negative osmotic potential.

157. (A) Pressure potential
The sign of pressure potential varies significantly depending on the tissue and physical state of transport. In the xylem vessels of a transpiring plant, water is pulled upward under tension, which creates a negative pressure potential. Conversely, in the phloem of a photosynthesizing leaf, active solute loading drives osmosis, establishing a high positive pressure potential.

158. (C) Abundant water availability
Aquaporins are highly regulated membrane channel proteins that facilitate the passive transport of water across cellular membranes. Their activity is regulated by phosphorylation, which is triggered under conditions of abundant water availability. This phosphorylation maintains the channels in an open state, enhancing the hydraulic conductivity of the tissue to allow rapid water movement.

159. (D) Plasma membrane Intrinsic Proteins (PIPs)
Diurnal regulation of root hydraulic conductance is highly correlated with the abundance and activity of the plasma membrane intrinsic proteins subfamily of aquaporins. These specialized channel proteins are located on the outer cellular boundary, where they actively control the rate of water entry into the symplastic pathway of root cells during changing transpirational demands.

160. (C) Leaf air spaces and the atmosphere.
The steepest drop in water potential along the soil-plant-atmosphere continuum occurs across the boundary between the internal air spaces of the leaf and the external bulk atmosphere. This massive gradient is driven by the low relative humidity of the air, which represents an extremely negative water potential compared to the hydrated leaf interior.

161. (B) Decrease to near zero
Passive water absorption is physically driven by the tension created by leaf transpiration. When a plant is placed in an atmosphere with one hundred percent relative humidity, the vapor pressure deficit between the leaf interior and the air falls to zero, halting transpiration. Consequently, the tension in the xylem disappears, causing passive absorption to decrease.

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162. (D) Endodermis
Active water absorption depends on solute accumulation in the root xylem, creating an osmotic gradient that pulls water inward. To maintain this hypertonic state within the vascular cylinder, the root endodermis acts as a selective barrier. Its suberized Casparian strip blocks the apolastic backflow of these ions, preventing them from leaking into the cortex.

163. (A) Regulate selective ion uptake and block toxins.
The suberized Casparian strip in the root endodermis is a critical physical barrier that blocks the apoplastic pathway. By forcing water and solutes to cross the selectively permeable plasma membrane of endodermal cells, it allows the plant to actively regulate selective mineral nutrient uptake while blocking toxic substances from entering the vascular system.

164. (C) Bordered pits or micro-porous pit membranes.
Xylem networks are vulnerable to cavitation, where air bubbles disrupt water transport. To

125. (A) Both A and R are true and R is the correct explanation of A.
Under early drought stress, plants close their stomata to limit transpirational water loss and conserve internal hydration. However, this protective response also restricts the diffusion of atmospheric carbon dioxide into the leaf interior. Consequently, photosynthetic carbon assimilation is reduced, which limits the production of carbohydrates and invariably decreases overall crop growth rates.

126. (C) Deep root penetration and branching in deeper soil horizons.
For effective drought avoidance, the most advantageous morphological modification of the root system is deep root penetration coupled with branching in lower soil layers. This allows the plant to tap into deep, stable water tables that remain hydrated long after the upper soil horizons have dried out, ensuring a continuous supply of water.

127. (D) Reduced sucrose production and loss of mesophyll turgor.
Drought stress impairs the process of phloem loading through multiple interconnected mechanisms. The primary causes are the reduction in sucrose production due to stomatal limitation of photosynthesis and the physical loss of turgor in mesophyll source cells. This turgor loss disrupts the hydrostatic pressure gradient required for driving the mass flow of photoassimilates.

128. (C) Calcium ions ($Ca^{\{2+\}}$)
Abscisic acid-mediated signaling in guard cells triggers a rapid increase in the concentration of cytoplasmic free calcium ions, which act as a key secondary messenger. This elevation of calcium activates calcium-dependent protein kinases, which in turn phosphorylate and activate slow anion channels, leading to membrane depolarization, solute efflux, loss of turgor, and stomatal closure.

129. (B) Plastids and cytoplasm
The biosynthesis of the stress hormone abscisic acid is a multi-step pathway that is compartmentalized within plant cells. The early steps of the pathway, which involve the cleavage of carotenoid precursors, take place in the plastids, while the final enzymatic conversions to produce active abscisic acid occur in the cytoplasm.

130. (D) Ephemeral annuals
The drought escape strategy is most typically observed in ephemeral annuals. These plants complete their entire life cycle rapidly during short periods of water availability, producing seeds before the onset of severe seasonal drought. This adaptation allows them to avoid experiencing dry periods as active vegetative plants, surviving instead as drought-tolerant seeds.

131. (A) Avoidance maintains hydration, while tolerance enables survival when dehydrated.
Drought avoidance and drought tolerance are two distinct physiological strategies. Avoidance involves structural or physiological mechanisms, such as deep roots or stomatal control, that maintain high tissue hydration during dry spells. In contrast, tolerance refers to the biochemical ability of cells to withstand severe dehydration and maintain structural and functional integrity under low water potentials.

132. (C) Active accumulation of solutes to maintain cell turgor.
Osmotic adjustment is an active physiological adaptation rather than a passive effect of cellular dehydration. It involves the active metabolic synthesis and accumulation of various organic and inorganic solutes within the cell. This process lowers the cellular solute potential, which drives water uptake and maintains vital cell turgor and volume despite dry conditions.

133. (A) They strongly inhibit key metabolic enzymes.
Compatible solutes, or osmolytes, are small organic compounds that accumulate in response to osmotic stress. They are highly water-soluble, carry a net neutral charge at physiological pH, and, crucially, do not inhibit metabolic enzymes or disrupt cellular macromolecules even at very high concentrations, thereby protecting cellular functions during periods of severe water deficit.

134. (D) LEA proteins
Late embryogenesis abundant proteins are a class of protective hydrophilic proteins that accumulate heavily during cellular desiccation. Under fully hydrated conditions, these proteins lack a stable secondary structure and are intrinsically disordered. During water loss, they assist in stabilizing membranes and sensitive enzymes, preventing denaturation and maintaining the structural integrity of the cytoplasm.

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driving that flow, reflecting the structural and functional efficiency of the xylem conduits and root systems.

175. (D) P-3, Q-2, R-1, S-4
The physiological responses of plants to water deficit are driven by specific mechanisms. Leaf rolling is caused by turgor loss in specialized bulliform cells, while stomatal closure is triggered by the efflux of potassium from guard cells. Osmotic adjustment involves active accumulation of proline and sugars, and root-to-shoot ratio changes result from differential organ growth sensitivity.

176. (C) Dense leaf pubescence
Dense leaf pubescence, which is the presence of fine epidermal hairs, is a classic morphological adaptation that reduces the radiation load on leaves. These hairs reflect solar radiation, cooling the leaf surface. Additionally, they trap a layer of humid air next to the epidermis, increasing boundary layer resistance and reducing transpirational water loss.

177. (B) Stomatal limitation of CO_2.
Under moderate drought stress, the initial reduction in photosynthetic carbon assimilation is primarily caused by stomatal limitation. To prevent excessive transpiration, plants close their stomata, which restricts the diffusion of atmospheric carbon dioxide into the leaf mesophyll. This depletion of internal carbon dioxide limits substrate available for the Rubisco enzyme.

178. (D) I, II and IV
Drought stress causes an imbalance between light absorption and carbon fixation, which promotes the transfer of excess energy to oxygen, forming reactive oxygen species. These highly reactive molecules are destructive, causing widespread damage to proteins, lipids, and nucleic acids alike. To mitigate this oxidative stress, plants rely heavily on the enzymatic ascorbate-glutathione cycle.

179. (A) Superoxide radical
Under severe drought, the reduction in carbon dioxide assimilation causes the photosynthetic electron transport chain to become highly over-reduced. Under these conditions, electrons are directly transferred from ferredoxin or other components to molecular oxygen rather than NADP plus. This single-electron reduction of oxygen produces the superoxide radical, which is the primary reactive oxygen species.

180. (C) The photosystem II reaction center.
Singlet oxygen is a highly reactive species produced during photosynthesis. When light absorption exceeds the capacity for carbon assimilation under drought, the excitation energy of chlorophyll cannot be dissipated. This energy is transferred from triplet-state chlorophyll to ground-state molecular oxygen, generating singlet oxygen primarily within the photosystem II reaction center of chloroplasts.

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181. (A) Drought avoidance
Abscisic acid-induced stomatal closure is a classic example of the drought avoidance strategy. By closing stomata in response to chemical signals of soil drying, the plant actively minimizes transpirational water loss. This rapid physiological adjustment maintains high internal water potential and leaf relative water content, avoiding cellular dehydration during periods of limited water availability.

182. (D) A deep taproot with steep growth angles.
Modifications of root system architecture are vital for drought avoidance. An adapted system is characterized by a deep taproot displaying steep growth angles. This vertical orientation allows roots to rapidly penetrate deeper soil layers where moisture levels remain high, ensuring sustained water uptake during prolonged dry periods when surface soils are completely depleted of water.

183. (B) Allometric shifting
During drought, plants exhibit developmental plasticity by shifting carbon allocation between organs. This process, known as allometric shifting, involves arresting shoot growth to conserve resources while actively promoting downward root growth. This shift in biomass partitioning increases the root-to-shoot ratio, optimizing water extraction capacity relative to the transpirational demand of the canopy.

184. (C) Osmotic adjustment
Osmotic adjustment is the hallmark of physiological drought tolerance. It is defined as the capability of a plant cell to actively accumulate solutes, which lowers its internal solute potential. This metabolic response creates a potential gradient that drives water entry,

204. (B) Decreased degradation by inhibition of proline dehydrogenase (PDH).
The dramatic accumulation of proline during drought stress is a highly regulated biochemical process. It is achieved through both the transcriptional activation of its biosynthetic genes and a concurrent decrease in its catabolism. This catabolic reduction is driven by the feedback inhibition of proline dehydrogenase, the key mitochondrial enzyme responsible for proline breakdown.

205. (B) Pyrroline-5-carboxylate synthetase (P5CS)
The biosynthesis of proline from glutamate is the main pathway in plants under stress. The rate-limiting enzyme in this pathway is pyrroline-five-carboxylate synthetase, which catalyzes the initial two-step conversion of glutamate to pyrroline-five-carboxylate. Under osmotic stress, expression of this gene is heavily upregulated, leading to the rapid accumulation of protective proline.

206. (C) Respiration
Under progressive water stress, different cellular and physiological processes display varying levels of sensitivity. Physical cell expansion and stomatal conductance are extremely sensitive, declining rapidly at very mild deficits. In contrast, cellular respiration is relatively stable and represents the least sensitive process, remaining active even under moderate to severe water stress.

207. (D) Drought avoidance
An increase in the synthesis and deposition of cuticular wax on leaf surfaces under drought is a classic example of drought avoidance. This structural modification enhances the cuticle barrier, reducing non-stomatal or cuticular transpiration. This water conservation mechanism maintains internal water status, allowing the plant to avoid severe tissue dehydration during prolonged dry spells.

208. (C) Oxidative stress
During severe drought stress, the imbalance between light absorption and carbon assimilation leads to the overproduction of reactive oxygen species in plant cells. This excess accumulation causes oxidative stress, a process that damages lipids, proteins, and DNA. It impairs membrane integrity and enzyme functions, ultimately leading to cellular degradation if left unchecked.

209. (B) Higher WUE and lower internal CO_2 concentration.
In C_3 plants, carbon isotope discrimination is closely linked to stomatal conductance and water use efficiency. A lower discrimination value indicates that the plant had lower stomatal conductance during growth, restricting internal carbon dioxide concentrations. This restriction forces Rubisco to fix more carbon thirteen, correlating directly with higher seasonal water use efficiency.

210. (D) Aerial thermal imaging to measure canopy temperature depression.
Aerial thermal imaging is the most appropriate high-throughput, non-destructive technique for assessing crop water status across large field breeding trials. By capturing canopy temperature depression from above, it identifies which plots are maintaining transpirational cooling under drought. This enables researchers to rapidly evaluate and select water-use-efficient genotypes among hundreds of plots simultaneously.

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mechanisms. Processes like xylem cavitation, lipid peroxidation, and leaf wilting are passive consequences of water stress. In contrast, the synthesis and accumulation of dehydrins represents an active, genetically regulated biochemical mechanism that plants deploy to protect cellular components from desiccation.

195. (A) Solutes bind water, reducing its free energy and activity.
Solute potential is always negative, and adding solutes to water decreases this value further. This occurs because solute molecules interact and bind with water molecules via hydration shells. This interaction restricts the movement of water molecules, reducing their free energy, chemical potential, and overall chemical activity compared to pure water in a standard state.

196. (C) Water retention in very dry soil or within dry seeds.
Matric potential is the component of water potential that arises from the physical adsorption of water molecules to solid surfaces. It is critically important in dry soils or within dry seeds, where free water is absent. In these scenarios, the highly negative matric potential of soil particles and seed colloids governs water movement and retention.

197. (A) Enhance membrane hydraulic conductivity for passive water flow.
The principal function of aquaporins is to enhance the hydraulic conductivity of cell membranes, allowing rapid, passive movement of water molecules along potential gradients. While water can slowly diffuse directly through lipid bilayers, aquaporins form highly selective channels that significantly accelerate this passive transport, allowing plants to regulate cellular water balance.

198. (D) Soil (-0.1 MPa) $\rightarrow$ Root (-0.5 MPa) $\rightarrow$ Leaf (-1.5 MPa) $\rightarrow$ Atmosphere (-100.0 MPa)
For transpiration to occur continuously, water must move passively along a thermodynamic gradient of decreasing water potential. This requires the soil to have the highest (least negative) water potential, followed by the roots, then the leaves, and finally the atmosphere, which has an extremely negative water potential due to low relative humidity.

199. (B) Transpiration is low and soil moisture is abundant.
Guttation is the exudation of liquid water droplets from specialized pores called hydathodes at leaf margins. This phenomenon occurs under conditions where transpiration rates are extremely low, such as during humid nights, while soil moisture is abundant. Active ion absorption in the roots builds positive pressure, pushing water out of the leaves.

200. (C) Carbon dioxide for the Calvin-Benson cycle.
Stomatal closure is a key protective response to drought stress that directly restricts transpirational water loss. However, because the stomatal pores serve as the entry pathway for gaseous exchange, closure also prevents the diffusion of atmospheric carbon dioxide into the leaf interior. This depletion of internal carbon dioxide limits substrate availability for the Calvin-Benson cycle.

201. (D) Total biomass produced per unit of water transpired.
At the whole-plant level, water use efficiency is defined as the total dry biomass produced by the plant per unit volume of water lost via transpiration. This ratio is a key physiological indicator of how productively a plant can use its absorbed water resources to synthesize carbon compounds and support vegetative and reproductive growth.

202. (A) Abscisic acid
Abscisic acid is the primary signaling molecule synthesized in plant roots experiencing soil drying. It is transported rapidly through the xylem transpiration stream to the shoots, where it acts on guard cells to trigger stomatal closure. This chemical mechanism allows the plant to coordinate a proactive response to water stress before leaf hydration declines.

203. (B) Reduces canopy transpiration surface, preventing lethal dehydration.
Leaf senescence induced by progressive drought is an evolutionary adaptation that helps protect the plant from lethal dehydration. By shedding older or less productive leaves, the plant significantly reduces its overall canopy surface area. This structural reduction minimizes the total transpirational water loss, allowing the plant to conserve remaining soil moisture for vital tissues.

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thereby maintaining cellular turgor, cell volume, and metabolic processes despite a declining leaf water potential.

185. (D) Betaine
In members of the Chenopodiaceae family, glycine betaine serves as the primary compatible osmolyte accumulated under drought and salinity. This quaternary ammonium compound is highly soluble and carries no net charge at physiological pH. It accumulates in both the chloroplast and cytoplasm, where it acts to adjust osmotic potential and protect enzyme structures from dehydration.

186. (A) They are intrinsically disordered and fold only upon target interaction.
Late embryogenesis abundant proteins are highly hydrophilic molecules that function as cellular protectants during extreme dehydration. Their structural key feature is that they are intrinsically disordered in their fully hydrated state. Upon physical desiccation, they undergo conformation transitions to fold, enabling them to stabilize sensitive macromolecules, maintain membrane structures, and prevent protein aggregation.

187. (B) K-segment
Dehydrins are a highly hydrophilic, structurally flexible subclass of late embryogenesis abundant proteins that accumulate in response to drought and cold. Biochemically, they are defined by the presence of at least one copy of a highly conserved, lysine-rich fifteen-amino-acid sequence known as the K-segment. This segment is essential for stabilizing membranes and macromolecules.

188. (B) I, II, III and V
Superoxide dismutase acts as the first enzymatic line of defense by converting superoxide to hydrogen peroxide. Catalase then detoxifies hydrogen peroxide in peroxisomes without using reducing equivalents, while ascorbate peroxidase utilizes ascorbate for its reduction. Alpha-tocopherol provides non-enzymatic lipid-soluble membrane protection. Conversely, glutathione reductase does not use ATP directly to reduce hydrogen peroxide.

189. (A) Stabilize structures, scavenge ROS, and buffer redox.
Proline is a multi-functional amino acid that accumulates dramatically in response to osmotic stress. In addition to serving as a compatible osmolyte that maintains cell turgor, it directly stabilizes sub-cellular structures like membranes and proteins. It also acts to scavenge reactive oxygen species and buffer cellular redox status, protecting organelles from oxidative damage.

190. (C) Water use efficiency (WUE)
Water use efficiency is a vital physiological parameter that integrates carbon assimilation and water loss, defined as the ratio of biomass produced or carbon dioxide fixed to the water transpired. This metric is a key trait used in crop breeding and phenotyping programs, as it directly reflects a plant's productivity under limited water.

191. (D) Less discrimination against ${}^{\{13\}}C$, yielding a higher tissue ratio.
During photosynthesis, the enzyme Rubisco discriminates against the heavier carbon isotope thirteen in favor of carbon twelve. When stomata are partially closed under drought, the internal carbon dioxide concentration decreases, forcing Rubisco to fix more available carbon thirteen. This leads to less discrimination against carbon thirteen, yielding a higher carbon isotope ratio in tissues.

192. (C) Electrolyte leakage assay
The electrolyte leakage assay is a direct, quantitative laboratory method used to evaluate the physical integrity of the plasma membrane. When membranes are damaged by severe desiccation or heat, their semi-permeability is compromised, causing solutes to leak out. Measuring the electrical conductivity of the bathing solution allows researchers to calculate cell membrane stability.

193. (B) Maintains stable, high economic yield under limited water.
From an agronomic perspective, a crop variety is classified as drought-tolerant if it maintains stable, high economic yield under water-limited conditions. While physiological traits like survival or stomatal closure are informative, the ultimate agricultural standard for tolerance is the ability to produce a harvestable product with minimal yield reduction compared to well-watered environments.

194. (D) Synthesis and accumulation of dehydrins.
Drought adaptation can involve passive responses to structural damage or active physiological

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CHAPTER 12
Irrigation Water Management

2019

1. The potential energy of water in soil, relative to pure water in a standard reference state, is referred to as soil water potential. Which component dominates water retention in unsaturated soils?
(A) Matric potential
(B) Osmotic potential
(C) Gravitational potential
(D) Pressure potential

2021

2. According to Darcy's Law, the rate of water flow through a porous medium is proportional to which of the following?
(A) Soil moisture content
(B) Local osmotic pressure
(C) Hydraulic gradient
(D) Dry soil bulk density

2006

3. Infiltration rate typically exhibits which pattern over time during a continuous rainfall event?
(A) Initial high rate decreasing to a constant
(B) Constant rate maintained from start to finish
(C) Initial low rate increasing to a steady maximum
(D) Random fluctuations influenced by soil depth

2002

4. Which of the following statements correctly describes capillary water in soils?
(A) It is held in the soil macropores and drains rapidly under gravity.
(B) It is extremely tightly bound to particles and unavailable to plants.
(C) It exists only in fully saturated conditions below the water table.
(D) It is held by surface tension in capillary pores and is largely available to plants.

2024

5. Consider the following statements regarding soil water potential:
I. Matric potential is generally negative in unsaturated soils.
II. Gravitational potential is positive above the reference plane.
III. Osmotic potential significantly influences mass flow in non-saline conditions.
Which of the above statements is/are correct?
(A) I, II and III
(B) I and II
(C) II and III
(D) I only

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2011

6. A farmer observes water pooling on a clayey field shortly after irrigation begins. Applying the concept of soil moisture movement, what is the most likely primary cause?
(A) Highly elevated saturated hydraulic conductivity
(B) Rapid capillary rise exceeding evaporation rate
(C) Infiltration rate lower than application rate
(D) Extremely high osmotic potential in the topsoil

2011

7. The hysteresis effect in soil moisture characteristics primarily leads to which of the following phenomena?
(A) Identical water retention in drying and wetting phases
(B) Significantly lower water content in drying than wetting
(C) Complete elimination of the characteristic air-entry value
(D) Higher water content during drying than during wetting

2023

8. Comparing clay and sand, which demonstrates the highest saturated hydraulic conductivity and which exhibits the highest total porosity?
(A) Sand has higher conductivity; clay has higher porosity.
(B) Clay has higher conductivity; sand has higher porosity.
(C) Sand has higher conductivity; sand has higher porosity.
(D) Clay has higher conductivity; clay has higher

(C) 10,000 to 50,000 hectares
(D) Greater than 50,000 hectares

2010
28. Which pre-independence famine commission extensively recommended the expansion of protective irrigation networks in India?
(A) Hunter Commission of 1882
(B) MacDonnell Commission of 1901
(C) Famine Commission of 1880
(D) Simon Commission of 1927

2022
29. Which component is most relevant for assessing the "actual evapotranspiration" (ETa) of a crop in the field?
(A) Direct wind speed and aerodynamic forces
(B) Theoretical solar radiation calculations
(C) Physical pan evaporimeter dimensions
(D) Field soil moisture availability

2008
30. Select the correct historical sequence of development of the following irrigation structures in India, from earliest to most recent:
(A) Grand Anicut → Western Yamuna Canal → Bhakra Dam
(B) Western Yamuna Canal → Grand Anicut → Bhakra Dam
(C) Bhakra Dam → Western Yamuna Canal → Grand Anicut
(D) Grand Anicut → Bhakra Dam → Western Yamuna Canal

2006
31. Which of the following statements correctly differentiates potential evapotranspiration (PET) from reference crop evapotranspiration (ET0)?
(A) PET is always applied to a specific standardized grass surface.
(B) ET0 is defined for a well-watered hypothetical grass crop.
(C) PET directly considers moisture stress, whereas ET0 does not.
(D) There is no conceptual difference between the terms PET and ET0.

2022
32. Crop coefficient (Kc) is defined as the ratio of which two parameters?
(A) Actual ET to Potential ET
(B) Reference ET (ET0) to Pan Evaporation (Ep)
(C) Transpiration to Evaporation
(D) Crop ET (ETc) to Reference ET (ET0)

2001
33. The aerodynamic method for estimating evapotranspiration is fundamentally classified under approaches that utilize which principles?
(A) Mass transfer and vapor transport
(B) Continuous soil moisture depletion tracking
(C) Plant physiological sap flow measurements
(D) Energy balance analysis purely via radiation

2004
34. Evapotranspiration is typically lowest during which phase of crop development?
(A) Initial stage
(B) Crop development stage
(C) Mid-season stage
(D) Late-season stage

2024
35. Arrange the standard FAO-56 crop growth stages in the correct chronological order for determining crop coefficients (Kc):
I. Mid-season
II. Initial
III. Late-season
IV. Crop development
Which of the following represents the correct sequence?
(A) II, I, IV, III
(B) II, IV, I, III
(C) IV, II, I, III
(D) I, II, III, IV

2014
36. If reference ET (ET0) is 5 mm/day and the mid-season crop coefficient (Kc) is 1.2, what is the estimated crop evapotranspiration (ETc) assuming no water stress?
(A) 4.2 mm/day
(B) 5.0 mm/day
(C) 6.0 mm/day
(D) 7.2 mm/day

2024
37. Which statement about the Penman-Monteith equation is INCORRECT?
(A) It requires air temperature, humidity, wind speed, and radiation data.
(B) It is only applicable for estimating evaporation from open water bodies.
(C) It incorporates both aerodynamic and surface resistance factors.
(D) It is recommended by FAO as the standard method for ET0 estimation.

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BCM
(B) Replenishable groundwater resources : 690 BCM
(C) Average annual precipitation : 4000 BCM
(D) Total utilizable water resources : 1869 BCM

2022
19. The largest proportion of India's annual precipitation is received during which specific meteorological period?
(A) South-West Monsoon
(B) Pre-monsoon showers
(C) North-East Monsoon
(D) Winter depressions

2010
20. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Groundwater depletion is severe in North-Western India.
Reason (R): The region relies heavily on paddy cultivation supported by heavily subsidized energy for pumping.
Which of the following is correct?
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2023
21. If an aquifer has high porosity but extremely low permeability, how will this affect its functionality for groundwater extraction?
(A) It will readily yield water rapidly to a pumping well.
(B) It holds water but yields it too slowly for use.
(C) It will act as a highly productive shallow aquifer.
(D) It will not hold or contain any groundwater at all.

2011
22. In the historical development of Indian irrigation, the Grand Anicut (Kallanai) was constructed across which river?
(A) Godavari
(B) Krishna
(C) Cauvery
(D) Mahanadi

2013
23. The construction of multi-purpose river valley projects causes significant downstream hydrological changes primarily due to what effect?
(A) Complete elimination of regional groundwater recharge
(B) Direct increase in the localized catchment rainfall
(C) Significant reduction in open water evaporation loss
(D) Altering natural flow and sediment trapping

2001
24. Which of the following is NOT classified as a major multi-purpose river valley project in India?
(A) Johad Water Harvesting System
(B) Bhakra-Nangal Reservoir Project
(C) Damodar Valley Multipurpose Project
(D) Hirakud Hydroelectric Project

2023
25. Match the multi-purpose project in List I with its associated river in List II.
List I: (Multi-purpose Project)
P. Bhakra-Nangal
Q. Hirakud
R. Sardar Sarovar
S. Nagarjuna Sagar
List II: (River)
1. Narmada
2. Krishna
3. Sutlej
4. Mahanadi
Which of the following is the correct combination?
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

2003
26. Comparing a major irrigation project to a minor irrigation project in India, which parameter primarily dictates the classification?
(A) Financial cost of construction
(B) Culturable Command Area (CCA)
(C) Height of the primary dam
(D) Distance from the water source to the fields

2023
27. According to Indian classification, a medium irrigation project has a Culturable Command Area (CCA) in which range?
(A) Less than 2,000 hectares
(B) 2,000 to 10,000 hectares

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(B) Extremely minimal deep percolation losses throughout the field
(C) Substantial surface runoff losses at the tail end of basin
(D) Excessive deep percolation near the inlet and dry far end

2019

65. Select the correct sequence of water advance phases in furrow irrigation:
(A) Advance phase → Storage phase → Depletion phase → Recession phase
(B) Storage phase → Advance phase → Recession phase → Depletion phase
(C) Advance phase → Depletion phase → Storage phase → Recession phase
(D) Recession phase → Storage phase → Advance phase → Depletion phase

2007

66. From the design guidelines of border irrigation, one can infer that longer borders are feasible under which conditions?
(A) Highly steep slopes and coarse sandy soils
(B) Irregular local topography and small stream sizes
(C) Flat slopes, clayey soils, and large streams
(D) Highly permeable soils regardless of ground slope

2010

67. Which of the following is NOT a recognized surface irrigation method?
(A) Center-pivot irrigation
(B) Corrugation surface irrigation
(C) Border basin flood irrigation
(D) Surge flow furrow irrigation

2009

68. The cutoff ratio in surface irrigation is defined as:
(A) Time required for recession divided by water advance time
(B) Total depth of root zone divided by soil infiltration rate
(C) Channel stream size divided by wetted cross-section perimeter
(D) Time of cutoff divided by total advance time

2007

69. Identify the correct statement regarding surge irrigation.
(A) It continuously applies water to the field without any interruption.
(B) It applies water intermittently in cycles to reduce infiltration.
(C) It is strictly applicable only to pressurized micro-irrigation systems.
(D) It significantly increases surface runoff and soil erosion losses.

2016

70. Arrange the following components of a typical drip irrigation system in order from the water source to the field:
I. Emitters
II. Mainline
III. Sand filter
IV. Sub-main and laterals
Which of the following represents the correct sequence?
(A) III, II, I, IV
(B) III, II, IV, I
(C) II, III, IV, I
(D) II, IV, III, I

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2016

71. In sprinkler irrigation, the application rate must be carefully designed to not exceed which soil property?
(A) Hydraulic conductivity at saturation
(B) Permanent wilting point
(C) Bulk density
(D) Basic infiltration rate

2002

72. A farmer wishes to apply soluble fertilizers directly into the root zone while maintaining precise soil moisture. Which system is most conceptually appropriate?
(A) Drip fertigation
(B) Wild flooding
(C) Furrow irrigation
(D) Sub-irrigation via drainage pipes

2014

73. Pitcher irrigation is a traditional, localized irrigation method classified under which broader operational category?
(A) Pressurized sprinkler nozzle systems
(B) Subsurface porous-wall irrigation
(C) Intermittent surge surface furrow flow
(D) Open channel gravity distribution

2005

74. Emitter clogging in drip irrigation is commonly caused by physical, chemical, or biological agents. Which chemical precipitate is most frequently responsible for clogging in calcareous waters?
(A) Iron sulfide
(B) Calcium carbonate
(C) Sodium chloride

2010
38. The inclusion of canopy resistance in the Penman-Monteith equation primarily accounts for which physiological cause?
(A) Leaf angle orientation restricting sunlight
(B) Root zone depth limitations
(C) Stomatal control of transpiration
(D) Albedo variations among crop varieties

2025
39. Given that the Blaney-Criddle method relies heavily on mean monthly temperature and daytime hours, one can infer that it is most likely to be inaccurate in regions with which characteristic?
(A) Constant equatorial temperature ranges
(B) Uniform seasonal daylight hours
(C) Highly consistent relative humidity
(D) Variable wind and advective heat

2005
40. Consider the following empirical evapotranspiration (ET) estimation methods and their primary meteorological inputs:
I. Thornthwaite - Mean air temperature
II. Hargreaves - Temperature and extraterrestrial radiation
III. Blaney-Criddle - Wind speed and relative humidity
Which of the above combinations is/are incorrect?
(A) III only
(B) I and II
(C) II and III
(D) I only

2024
41. Consumptive use of water by a crop encompasses evapotranspiration plus which other component?
(A) Deep percolation losses below root zone
(B) Water used for metabolic processes
(C) Surface runoff losses from the field
(D) Water retained in the local soil profile

2023
42. Effective rainfall in the context of crop water requirements is best defined as:
(A) Total rainfall received during a calendar year
(B) Rainfall stored in the root zone for crop use
(C) Rainfall measured in a standard non-recording gauge
(D) Total rainfall minus potential evapotranspiration

2006
43. The "critical growth stage" for moisture stress is defined as:
(A) The stage where water stress causes maximum yield loss.
(B) The stage when the crop consumes the maximum amount of water.
(C) The stage when the crop exhibits the highest transpiration rate.
(D) The final physiological maturity stage prior to crop harvest.

2001
44. Comparing wheat and rice, how do their critical moisture sensitive stages primarily differ?
(A) Wheat is sensitive at tillering; rice is not sensitive at any growth stage.
(B) Both crops are strictly sensitive only during the initial seedling stage.
(C) Wheat is sensitive at CRI; rice is sensitive at panicle initiation.
(D) Rice requires stress at booting stage; wheat requires standing water.

2010
45. Consider the following crops and their primary critical stages for irrigation:
I. Maize - Tasseling and silking
II. Groundnut - Pegging and pod formation
III. Chickpea - Pre-flowering and pod development
IV. Sugarcane - Maturity and ripening
Which of the above combinations are correct?
(A) I, II and IV
(B) II and IV
(C) I, II, III and IV
(D) I, II and III

2009
46. For most oilseed crops, moisture stress is particularly detrimental during which physiological phase?
(A) Early vegetative crop growth stage
(B) Post-maturity crop desiccation
(C) Flowering and seed development
(D) Late physiological senescence

2001
47. A farmer has a limited water supply sufficient for only one irrigation for a wheat crop. Applying knowledge of critical stages, at what stage should this irrigation be applied?
(A) Active stem jointing growth stage
(B) Crown Root Initiation (CRI)
(C) Active anthesis/flowering
(D) Late grain milk/dough stage

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2022

85. Consider the following statements concerning antitranspirants used to enhance Water Use Efficiency (WUE):

I. Stomatal closing types (e.g., PMA) reduce transpiration but also restrict CO_2 diffusion.
II. Film-forming types (e.g., Mobileaf) form a physical barrier over the leaf surface.
III. Reflectant types (e.g., Kaolin) increase leaf temperature.
IV. Growth retardants (e.g., Cycocel) increase root growth and drought resistance.
V. Antitranspirants are widely and economically used in large-scale cereal production.

Which of the above statements are correct?
(A) I, II and III
(B) I, II and IV
(C) I, II, III and V
(D) II, IV and V

2018

86. Conjunctive use of water resources in a command area primarily implies:
(A) Exclusive utilization of groundwater for crop irrigation
(B) Blending canal water with treated municipal wastewater
(C) Coordinated use of surface and groundwater
(D) Alternating crops in sequential agricultural seasons

2004

87. In regions with rising water tables due to excessive canal irrigation, conjunctive use is implemented primarily to control which problem?
(A) Highly severe soil acidity
(B) Accelerated local wind erosion
(C) Severe chemical fertilizer leaching
(D) Waterlogging and salinization

2001

88. A common technique for the conjunctive use of saline groundwater and fresh canal water is:
(A) Fresh water at sensitive stages, saline water at tolerant stages
(B) Applying both sources sequentially without considering specific crop stage
(C) Evaporating the saline groundwater resource fully before actual application
(D) Injecting canal water deep into saline aquifers during active crop growth

2019

89. Which scenario is NOT an example of integrated rainwater and groundwater management?
(A) Directing rooftop rainwater into recharge borewells
(B) Lining canals fully to prevent any seepage to the aquifer
(C) Constructing percolation tanks to replenish shallow aquifers
(D) Using supplemental groundwater pumping during dry spells in a rainfed area

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2009

90. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Deficit irrigation strategies intentionally apply less water than the maximum crop evapotranspiration requirement.

Reason (R): The primary objective of deficit irrigation is to completely eliminate yield losses under drought conditions.

Which of the following is correct?
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2021

91. Based on the concept of Regulated Deficit Irrigation (RDI), one can infer that imposing water stress during specific phenological stages in fruit trees often leads to:
(A) Improved fruit quality and controlled vigor
(B) Complete physiological decline and death of the tree
(C) Massive increases in total vegetative canopy biomass
(D) Complete reduction to zero crop evapotranspiration

2022

92. Identify the correct pair regarding water quality indices.
(A) Electrical Conductivity (EC) : Directly measures specific ion toxicity of boron
(B) Residual Sodium Carbonate (RSC) : Measures the sum of chloride and sulfate ions
(C) SAR : Evaluates sodium hazard relative to calcium and magnesium
(D) pH : Acts as a direct quantitative measure of total dissolved solids in water

2002

93. If irrigation water has an Electrical Conductivity (EC) of 4.0 dS/m, it is conceptually classified as:

2025

56. In the context of canopy temperature indices, what does the Crop Water Stress Index (CWSI) quantify?

(A) Relative crop water stress based on canopy-to-air temperature differences and vapor pressure deficit

(B) The ratio of sensible heat flux to latent heat flux in canopy

(C) The absolute difference between air and soil temperature levels

(D) The total absorbed photosynthetically active radiation by leaves

2001

57. A thermal infrared thermometer indicates that a crop canopy is significantly warmer than the ambient air under sunny conditions. What does this indicate?

(A) The crop canopy is actively transpiring at maximum potential.

(B) Stomatal closure is restricting transpirational cooling.

(C) The crop is suffering from a localized foliar fungal infection.

(D) Soil moisture profile is maintained exactly at field capacity.

2002

58. Which plant-based technique provides rapid, non-destructive, and continuous monitoring of water status?

(A) Measuring relative water content (RWC) via leaf excision

(B) Sap flow sensor installation

(C) Using a Scholander pressure chamber

(D) Gravimetric root sampling

2013

59. Indicator plants used in irrigation scheduling typically possess which characteristic?

(A) Early visible wilting symptoms relative to main crop

(B) Highly pronounced genetic drought tolerance in dry environments

(C) Extremely deep and highly branched taproot systems in soil

(D) Extremely low transpiration rates during peak solar radiation

2003

60. Match the irrigation water measurement structure in List I with its specific operational feature in List II.

List I: (Measurement Structure)

P. V-notch weir

Q. Parshall flume

R. Dethridge meter

S. Orifice plate

List II: (Operational Feature)

1. Functions efficiently under submerged flow with low head loss
2. Volumetric measurement wheel
3. Measures very low discharges accurately
4. Flow through a restricted opening under pressure

Which of the following is the correct combination?

(A) P-3, Q-1, R-4, S-2

(B) P-2, Q-4, R-1, S-3

(C) P-3, Q-1, R-2, S-4

(D) P-1, Q-2, R-3, S-4

2018

61. Comparing a rectangular weir and a Parshall flume for flow measurement in an irrigation channel, what is a primary advantage of the Parshall flume?

(A) It requires a much larger drop in water surface elevation head.

(B) It is significantly cheaper and much easier to construct in field.

(C) It directly measures local water velocity rather than discharge.

(D) It is self-cleaning and handles high sediment loads.

2024

62. The standard formula for discharge over a 90° V-notch weir is proportional to the head (H) raised to what power?

(A) $H^{\frac{1}{2}}$

(B) $H^{\frac{3}{2}}$

(C) $H^{\{2\}}$

(D) $H^{\frac{5}{2}}$

2022

63. Volumetric water measurement using a simple container and stopwatch is most practical for assessing discharge from which source?

(A) Wide unlined earthen irrigation canal

(B) Drip emitter or low-yield well pipe

(C) Major natural flowing river channel

(D) Large multi-bay reservoir spillway

2010

64. The application of check basin irrigation to highly permeable sandy soils usually results in which effect?

(A) Highly uniform water distribution across the entire basin area

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2013

48. To maximize yield under optimal conditions, irrigation scheduling based on allowable depletion aims to maintain soil moisture in which specific range?
(A) Between Saturation and Field Capacity moisture levels
(B) Between Permanent Wilting Point and Hygroscopic Coefficient
(C) Constantly maintained at soil saturation capacity
(D) Between Field Capacity and allowable depletion limit

2022

49. Which of the following instruments is NOT suitable for direct measurement or scheduling based on soil matric potential?
(A) Neutron moisture meter
(B) Tensiometer
(C) Granular matrix sensor
(D) Gypsum block

2014

50. Consider the following statements regarding soil moisture measurement devices:
I. Tensiometers operate effectively up to -15 bars tension.
II. Gypsum blocks dissolve over time in wet soils.
III. Time Domain Reflectometry (TDR) measures soil dielectric constant.
IV. Neutron probes use a radioactive source (Americium-Beryllium).
V. Gravimetric method requires oven drying at 105°C.
Which of the above statements is/are incorrect?
(A) II and III
(B) I, III and V
(C) I only
(D) IV and V

2017

51. Air entry into a tensiometer at tensions greater than 0.8 bars causes which functional failure?
(A) The vacuum breaks, causing incorrect readings.
(B) The porous ceramic cup shatters under pressure.
(C) Water is pushed rapidly into the surrounding soil.
(D) The mercury column expands beyond physical limits.

2019

52. Permissible or management allowable depletion (MAD) is typically set at what percentage of Available Water Capacity for most drought-sensitive crops?
(A) 10-15%
(B) 25-50%
(C) 75-90%
(D) 100%

2003

53. The IW/CPE ratio used in climatological irrigation scheduling refers to the ratio of:
(A) Infiltrated Water to Crop Potential Evapotranspiration
(B) Irrigation Water applied to Cumulative Pan Evaporation
(C) Initial Water content to Capillary Potential Energy
(D) Irrigation Water to Consumptive Plant Evaporation

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2010

54. Which pair correctly links an IW/CPE ratio to the implied irrigation frequency?
(A) 1.2 : Less frequent irrigation with larger water intervals
(B) 0.6 : High frequency irrigation with very small intervals
(C) 1.0 : Irrigation depth equals cumulative evaporation
(D) 0.4 : Low frequency irrigation applied on a daily basis

2022

55. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Pan evaporation readings must be adjusted using a pan coefficient (Kp) to estimate reference crop ET.
Reason (R): The pan coefficient accounts for the differences in aerodynamic characteristics and albedo between the water surface and the reference grass.
Which of the following is correct?
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

(D) Potassium nitrate compounds

2006

75. Consider the following statements regarding micro-irrigation:

I. Drip irrigation generally achieves higher application efficiency than border irrigation.
II. Sprinkler irrigation is highly suitable for heavy clay soils with very low infiltration rates.
III. Micro-irrigation reduces weed growth between rows compared to flooding.

Which of the above statements is/are correct?
(A) I and III
(B) II and III
(C) I and II
(D) I only

2022

76. Subsurface drip irrigation (SDI) prevents evaporation losses from the soil surface but faces which unique maintenance challenge?
(A) Excessive wind drift
(B) Runoff accumulation
(C) Root intrusion into emitters
(D) High evaporative demand on laterals

2016

77. Water conveyance efficiency (E_c) is mathematically defined as:
(A) Water stored in the root zone divided by total water delivered to the field
(B) Crop evapotranspiration divided by total volume of irrigation water applied
(C) Water beneficially used divided by total water lost to deep percolation
(D) Water delivered to field divided by water diverted from source

2005

78. Poorly maintained unlined earthen canals will cause a drastic reduction in which specific efficiency metric?
(A) Water application efficiency
(B) Water storage efficiency
(C) Water conveyance efficiency
(D) Consumptive use efficiency

2010

79. Comparing surface flooding with drip irrigation, which efficiency parameter shows the most dramatic improvement under drip?
(A) Conveyance efficiency
(B) Application efficiency
(C) Pumping efficiency
(D) Reservoir storage efficiency

2003

80. Consider the following statements regarding irrigation efficiencies:

I. Application efficiency rarely exceeds 60% in unlined furrow irrigation.
II. Uniformity coefficient evaluates the evenness of water distribution.
III. Storage efficiency is higher when the root zone is heavily under-irrigated.
IV. Water Use Efficiency (WUE) is expressed in kg/ha-mm.

Which of the above statements is/are incorrect?
(A) I and II
(B) II and III
(C) I and IV
(D) III only

2022

81. If a field requires 60 mm of water in the root zone to reach field capacity, and 100 mm of water is applied to the field to achieve this, what is the Water Application Efficiency?
(A) 40%
(B) 60%
(C) 100%
(D) 160%

2015

82. Which of the following practices actively improves water distribution efficiency?
(A) Increasing field length indiscriminately
(B) Using variable slope in border strips
(C) Precise land leveling and grading
(D) Using highly saline water

2017

83. Field Water Use Efficiency (FWUE) is calculated as crop yield divided by:
(A) Total water applied, rainfall, and soil water
(B) Total crop evapotranspiration loss during season
(C) Total seasonal water requirement of the crop
(D) Baseflow of the stream system in catchment

2014

84. Identify the INCORRECT statement regarding agronomic methods to enhance Water Use Efficiency (WUE).
(A) Application of organic mulches reduces soil evaporation, enhancing overall WUE.
(B) Cultivating drought-tolerant, short-duration varieties generally improves WUE.
(C) Optimal plant population geometry increases the intercepted radiation, boosting WUE.
(D) Excessive nitrogen fertilization maximizes WUE under severe drought.

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porosity.

2024

9. The pF scale expresses soil moisture tension as the logarithm of the capillary head in centimeters. What is the pF value corresponding to Field Capacity?
(A) 0.00
(B) 2.53
(C) 4.18
(D) 7.00

2024

10. Consider the following statements regarding soil moisture constants:
I. Permanent Wilting Point occurs uniformly at -0.33 bar for all crops.
II. Available Water Capacity is the difference between saturation and field capacity.
III. The pF value for oven-dry soil is approximately 7.0.
IV. Hygroscopic coefficient indicates moisture at -31 bars tension.
Which of the above statements are incorrect?
(A) I, II and IV
(B) I and II
(C) III and IV
(D) I, II and III

2006

11. Which pair INCORRECTLY matches the soil moisture constant to its associated pressure limit?
(A) Hygroscopic coefficient : -15 bar
(B) Field capacity : -0.1 to -0.33 bar
(C) Permanent wilting point : -15 bar
(D) Ultimate wilting point : -60.0 bar

2008

12. Which soil texture generally retains the maximum amount of plant-available water?
(A) Coarse sand
(B) Sandy loam
(C) Silt loam
(D) Heavy clay

2023

13. Based on the classification of soil water availability, moisture held at a tension between 15 and 31 atmospheres is functionally categorized as what for most agricultural crops?
(A) Readily available water
(B) Gravitational water
(C) Excess water
(D) Unavailable water

2011

14. If a soil sample's mass wetness decreases sharply while the volume remains constant, one can infer that the soil moisture state has passed which specific threshold during drying?
(A) Field capacity
(B) Saturation capacity
(C) Shrinkage limit
(D) Liquid limit

2015

15. Consider the following statements regarding the hydrological cycle components:
I. Precipitation includes rainfall, snow, and dew.
II. Interception loss reaches the groundwater directly.
III. Transpiration is a biological process of water loss.
IV. Runoff only occurs when infiltration capacity is zero.
V. Percolation is the downward movement of water through the soil profile.
Which of the above statements is/are correct?
(A) I, II and IV
(B) I, III and V
(C) I, III, IV and V
(D) III and V

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2001

16. The concept of "baseflow" in hydrology is most accurately defined as which of the following?
(A) Surface runoff measured during a peak storm event
(B) Water moving downward through the unsaturated zone
(C) Direct evaporation losses from open water bodies
(D) Streamflow derived from groundwater seepage

2001

17. Which equation best represents the general water balance of a catchment over a specified time period?
(A) $P - R - G - E - T = \Delta S$
(B) $P = E + R$
(C) $P + R = E + \Delta S$
(D) $R = P - \Delta S$

2003

18. Which paired estimate of India's water resources is generally accepted as correct by the Central Water Commission?
(A) Utilizable surface water resources : 1123

(A) Low salinity water classification
(B) Medium salinity water classification
(C) High salinity water classification
(D) Very high salinity water

2024
94. The continuous use of irrigation water with a high SAR and low EC is factually known to cause:
(A) Highly increased soil aggregation and high water permeability
(B) A very rapid and significant decrease in overall soil pH
(C) Soil dispersion and reduced infiltration
(D) Immediate and highly severe iron toxicity symptoms in plants

2003
95. Match the specific ion toxicity in List I with its typical symptom or context in List II.
List I: (Ion Toxicity)
P. Boron toxicity
Q. Chloride toxicity
R. Sodium toxicity
S. Bicarbonate toxicity
List II: (Symptom/Context)
1. Causes leaf marginal necrosis and burning
2. Induces iron chlorosis by immobilizing iron
3. Causes tip burn and accumulation in woody species
4. Yellowing and necrosis at leaf tips and margins; typical in arid zones
Which of the following is the correct combination?
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-4, S-2

2010
96. When applying the concept of leaching requirement (LR) for salinity management, the LR fraction is functionally dependent on which parameters?
(A) Soil temperature and ambient air humidity
(B) Average wind speed and physical crop height
(C) Total annual rainfall and soil organic matter
(D) EC of irrigation and soil drainage water

2003
97. What is the primary purpose of the Warabandi system in Northern India?
(A) Equitable and rotational distribution of canal water
(B) Active flood control and storm water drainage during monsoons
(C) Collection of water taxes and pricing purely by private entities
(D) Large-scale pumping of deep groundwater for local communities

2008
98. The Command Area Development (CAD) program in India was initiated specifically to bridge the gap between:
(A) Local groundwater recharge and extraction rates
(B) High-demand urban and rural domestic water supply
(C) Irrigation potential created and utilized
(D) Chemical fertilizer demand and domestic production

2024
99. Which classification accurately describes the structural hierarchy of a large canal distribution network?
(A) Main canal → Branch canal → Distributary → Minor → Watercourse
(B) Watercourse → Main canal → Minor → Distributary → Branch canal
(C) Main canal → Distributary → Branch canal → Watercourse → Minor
(D) Branch canal → Main canal → Watercourse → Minor → Distributary

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2006
100. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Participatory Irrigation Management (PIM) involves the transfer of irrigation management responsibilities from government agencies to farmers.
Reason (R): PIM ensures that the government completely stops funding all major dam constructions.
Which of the following is correct?
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2006
101. The establishment of Water User Associations (WUAs) generally leads to which effect at the tertiary canal level?
(A) Highly decreased crop yields due to constant water conflict

(B) Transition to corporate ownership and commercial financial management of water supply dams
(C) Allow transnational trade of bulk water across sovereign borders
(D) Completely abolish municipal water tariffs and fee charges

2021

180. The first National Water Policy in India was adopted in which year?
(A) 1950
(B) 1987
(C) 2002
(D) 2012

2007

181. Which of the following statements is correct regarding groundwater rights and legislation in India?
(A) Groundwater ownership rights are legally fully separated from surface land ownership.
(B) Groundwater rights are tied to land ownership, which often leads to unregulated extraction.
(C) The central government physically distributes all municipal groundwater.
(D) There are absolutely no functional state-level regulatory groundwater authorities.

2010

182. What is a primary function of the Central Ground Water Board (CGWB) in India?
(A) Designing and building large hydraulic dams
(B) Marketing commercial agricultural crop products
(C) National monitoring and assessment of groundwater resources
(D) Managing regional transport railway infrastructure

2003

183. What is the primary objective of implementing volumetric water pricing in agricultural policy?
(A) Discourage intensive farming and commercial agricultural activities completely
(B) Maximize fiscal revenues for federal and state governments
(C) Provide completely free electricity and fuel subsidies for well pumping
(D) Encourage water conservation by linking charges to the actual volume of water consumed

2025

184. The most appropriate strategy to manage irrigation in regions with severe and persistent groundwater overdraft is:
(A) Combining conjunctive use, crop diversification, and micro-irrigation
(B) Increasing electricity and energy subsidies for deeper water pumps
(C) Flooding fields with massive water depths during the monsoon rains
(D) Banning all commercial agriculture and cropping in overdraft basins

2002

185. Deforestation in the upper catchment of a river valley project primarily leads to:
(A) Substantially increased river baseflow volumes during dry summer seasons
(B) Accelerated soil erosion leading to reservoir siltation and reduced storage capacity
(C) Significant physical improvement of downstream chemical water quality
(D) Measurable reduction in mechanical hydrostatic water pressure on dams

2016

186. In the warabandi system, the "water allowance" is defined as the:
(A) Total volume of water a farmer is permitted to store in private farm ponds
(B) Design water discharge rate at the outlet per unit of culturable command area
(C) Total annual depth of water allowed for high-water-demand crops
(D) Subsidy amount provided to farmers for installing micro-irrigation systems

2012

187. Which of the following is NOT a benefit typically associated with successful Water User Associations (WUAs)?
(A) Creation of local monopolies over water distribution by large landowners
(B) Improved conflict resolution among farmers
(C) More equitable water distribution between head and tail-reach farmers
(D) Enhanced collective bargaining and community empowerment

2024

188. In India, water is constitutionally a State subject, but the Union government intervenes under specific conditions, primarily concerning:
(A) Management of minor local irrigation ponds
(B) Construction of community village well sites
(C) Regulation of inter-state rivers and valleys

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correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2014
111. Which law or principle governs the upward movement of water from a shallow water table into the root zone?
(A) Stokes' law of particle sedimentation
(B) Capillary rise equation of pore suction
(C) Poiseuille's law of viscous fluid flow
(D) Fick's law of molecular solute diffusion

2009
112. The most appropriate empirical equation used to estimate reference crop evapotranspiration (ET_0) when only temperature and geographical coordinates are available is:
(A) Penman-Monteith equation
(B) Priestley-Taylor equation
(C) Aerodynamic equation
(D) Hargreaves-Samani equation

2006
113. Which of the following statements is correct regarding crop coefficients (K_c)?
(A) The K_c for a crop is typically highest during the mid-season stage when the canopy is fully developed.
(B) K_c values remain completely constant from sowing to harvest.
(C) K_c is independent of the crop type.
(D) The basal crop coefficient integrates both transpiration and soil evaporation strictly into one unchanging value.

2011
114. In rainfed agriculture, the primary objective of "life-saving irrigation" is the:
(A) Complete elimination of external nutrient and fertilizer inputs
(B) Indefinite extension of the physiological vegetative growth period
(C) Prevention of permanent wilting and catastrophic crop failure
(D) Rapid accumulation of soil salinity from minimal water applications

2001
115. Match the physiological index in List I with its primary method of measurement in List II:
List I: (Physiological index)
P. Leaf water potential
Q. Stomatal conductance
R. Canopy temperature
S. Sap flow
List II: (Method of measurement)
1. Infrared thermometer
2. Scholander pressure chamber
3. Heat pulse velocity sensors
4. Porometer
Choose the correct option from the following:
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

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2023
116. What is the primary indicator used when scheduling irrigation via the "feel and appearance" method?
(A) Soil temperature monitoring via deep probe sensors
(B) Leaf color determination with standard chlorophyll meters
(C) Plant height measurement at critical vegetative nodes
(D) Visual and tactile assessment of soil sample moisture

2025
117. Which of the following is NOT an advantage of micro-sprinkler irrigation over drip irrigation?
(A) Provides micro-climate modification (cooling)
(B) Absolutely no evaporation losses during application
(C) Better suited for crops requiring a larger wetted soil volume, like mature orchard trees
(D) Less susceptible to complete clogging from small particles

2019
118. In canal water distribution, "Warabandi" or rotational water supply is primarily designed to ensure:
(A) Unrestricted continuous water allocation to head-reach fields
(B) Strict regulatory restrictions on private groundwater pumping
(C) Timely and equitable water delivery to all command area farmers
(D) Dedicated domestic water supply provision to rural settlements

2006
119. A "Command Area" is fundamentally defined as:

(A) The land buffer zone around a major reservoir strictly reserved for forestry
(B) The total gross geographic territory managed by local water user associations
(C) The low-lying floodplain zone along a river basin that gets flooded annually
(D) The land area that can be physically and economically irrigated by a project

2016

120. Residual Sodium Carbonate (RSC) is an irrigation water quality parameter calculated using the concentrations of which ions?
(A) Carbonate, Bicarbonate, Calcium, and Magnesium
(B) Sodium, Calcium, and Magnesium
(C) Carbonate, Bicarbonate, Chloride, and Sulfate
(D) Sodium, Potassium, and Boron

2004

121. The "leaching fraction" is defined as:
(A) The proportion of applied water that evaporates directly from the soil
(B) The fraction of applied irrigation water that drains below the root zone
(C) The percentage of nutrients taken up by the plant
(D) The ratio of crop transpiration to total evaporation

2019

122. If highly saline water is used for irrigation without adequate leaching or drainage, which of the following will occur?
(A) The physical structure of the soil will improve through rapid salt flocculation.
(B) Soil osmotic potential will drop, severely restricting plant water uptake.
(C) The soil permanent wilting point value will decrease towards zero bars.
(D) Crop transpiration rates will increase rapidly due to salt stimulation.

2010

123. Urea applied through a fertigation system first hydrolyzes into which compound in the soil?
(A) Ammonium
(B) Nitrate
(C) Nitrite
(D) Urea-formaldehyde

2014

124. Which of the following pairs correctly represents an irrigation efficiency or uniformity parameter and its formula?
(A) Storage Efficiency : $\frac{\text{Water delivered to the field}}{\text{Water needed in the root zone}} \times 100$
(B) Application Efficiency : $\frac{\text{Water delivered to the field}}{\text{Water stored in the root zone}} \times 100$
(C) Distribution Uniformity : $\frac{\text{Average depth of lowest quarter in filtrated}}{\text{Average depth in filtrated}} \times 100$
(D) Conveyance Efficiency : $\frac{\text{Water diverted from the main source}}{\text{Water delivered to the field}} \times 100$

2016

125. Which of the following irrigation methods typically has the highest theoretical application efficiency?
(A) Furrow irrigation
(B) Check basin irrigation
(C) Wild flooding
(D) Subsurface drip irrigation

2003

126. What is the primary agronomic objective of implementing "regulated deficit irrigation" in a vineyard?
(A) Increase the total surface area and size of the vine leaves
(B) Maximize overall vegetative biomass and canopy production
(C) Improve grape quality by restricting vegetative canopy growth
(D) Enhance the downward leaching of harmful accumulated salts

2008

127. Compared to the Penman-Monteith method for scheduling irrigation, the pan evaporation method is:
(A) Highly complex, requiring advanced multi-parameter climatic sensors
(B) Simpler, but highly vulnerable to localized micro-environmental errors
(C) Generally more reliable and accurate under diverse climatic conditions
(D) Entirely independent of atmospheric wind speed and solar radiation

2016

128. According to the National Water Policy of India, the first priority for the allocation of water resources is:
(A) Irrigation
(B) Hydro-power
(C) Industrial use

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(D) Drinking water

2022
129. "Net irrigation requirement" (NIR) is mathematically defined as:
(A) Evapotranspiration minus effective rain and soil moisture contribution
(B) Evapotranspiration plus deep leaching and percolation requirements
(C) Total irrigation water applied divided by system application efficiency
(D) Potential crop evapotranspiration minus localized pan evaporation

2008
130. The soil moisture content after free drainage of gravitational water has ceased, typically 2–3 days after saturation, is called:
(A) Hygroscopic coefficient
(B) Saturation capacity
(C) Field capacity
(D) Permanent wilting point

2009
131. Which of the following parameters is most relevant for calculating the gross irrigation requirement (GIR)?
(A) Overall irrigation efficiency
(B) The osmotic potential of the groundwater
(C) The color of the soil
(D) The latent heat of vaporization

2013
132. The process of transpiration causes leaf cooling primarily because:
(A) Water transfers low thermal energy from deep soil layers.
(B) Specialized plant stomata actively reflect incoming solar radiation.
(C) Leaf water absorbs specific heat energy without undergoing phase changes.
(D) Phase change of liquid water to vapor consumes significant latent heat.

2011
133. Which of the following is NOT a typical component of a standard US Class A Evaporation Pan?
(A) Stilling well
(B) Vacuum tensiometer tube
(C) Hook gauge
(D) Wooden support pallet

2019
134. Drip irrigation systems typically operate within which pressure range?
(A) 0.1 to 0.2 kg/cm^2
(B) 1 to 2 kg/cm^2
(C) 5 to 7 kg/cm^2
(D) 10 to 15 kg/cm^2

2012
135. In drip fertigation, injecting the fertilizer solution during the middle of the irrigation run rather than at the very beginning is primarily done to:
(A) Maximize the precipitation of nutrients in the main pipelines
(B) Prevent the nutrient solution from reaching the outer boundaries of the wetted soil volume
(C) Minimize leaching of nutrients below the root zone while allowing subsequent flushing
(D) Increase evaporation losses from the soil surface

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2019
136. Which of the following statements regarding water movement in soils is INCORRECT?
(A) Unsaturated flow is driven purely by gravitational potential.
(B) Water moves from regions of high potential to low potential.
(C) Capillary movement can occur in any direction.
(D) Hydraulic conductivity decreases as soil moisture content decreases.

2013
137. The total area of land enclosed within the boundary of an irrigation project, including both cultivable and non-cultivable land, is called:
(A) Culturable Command Area (CCA)
(B) Gross Command Area (GCA)
(C) Net Irrigated Area
(D) Gross Cropped Area

2004
138. A cone of depression forms around a pumping well because:
(A) The physical pumping action structurally collapses the surrounding soil
(B) Water is extracted faster than the aquifer's lateral flow can replenish it
(C) The regional aquifer's hydraulic transmissivity increases drastically
(D) Surrounding atmospheric pressure directly depresses the local water table

2012
139. The "safe yield" of an aquifer is defined as:
(A) The maximum quantity of water that can

(B) Better field channel maintenance and fee collection
(C) Complete and total depletion of local groundwater reserves
(D) Over-centralization of water policy at the national level

2001
102. In the context of water legislation, the "riparian rights" doctrine historically implies that:
(A) Water resources belong exclusively to the local state government.
(B) Water rights are sold to the highest bidder in open market systems.
(C) Adjoining landowners have rights to reasonable water use.
(D) Groundwater extraction requires no regulatory permits whatsoever.

2018
103. Under the Indian Constitution, "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power" is fundamentally listed under:
(A) The Union List
(B) The Concurrent List
(C) The Municipal List
(D) The State List

2004
104. Which framework provides the guiding principles for the equitable allocation, conservation, and pricing of water across states in India?
(A) National Water Policy
(B) Command Area Development Act
(C) Groundwater Extraction Guidelines
(D) MGNREGA

2021
105. Match the nitrogen fertilizer form in List I with its mobility in soils under heavy irrigation in List II.

List I: (Fertilizer Form)
P. Nitrate (NO_3^-)
Q. Ammonium (NH_4^+)
R. Urea (amide form)
S. Organic N

List II: (Mobility in Soils)
1. Highly mobile before hydrolysis
2. Mineralizes slowly, essentially immobile
3. Highly mobile, highly susceptible to leaching
4. Held on cation exchange sites, moderately restricted mobility

Which of the following is the correct combination?
(A) P-1, Q-4, R-3, S-2
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-4, S-2

2007
106. Applying nitrogen fertilizer just before a heavy basin irrigation event in a sandy soil will most likely result in:
(A) Enhanced symbiotic nitrogen fixation
(B) Severe nitrate leaching below root zone
(C) Rapid ammonia volatilization to the air
(D) Temporary immobilization by soil microbes

2006
107. Phosphorus fertigation via drip systems is often problematic primarily due to:
(A) Chemical precipitation and emitter clogging
(B) Extreme toxicity to sensitive crop roots
(C) Rapid volatilization into atmospheric gases
(D) Strict requirement of saturated soil conditions

2005
108. Chemigation is defined as:
(A) The chemical reclamation of highly saline agricultural soils using gypsum
(B) The application of specialized sealants to minimize canal seepage losses
(C) The application of agricultural chemicals through irrigation systems
(D) The chemical sterilization of contaminated irrigation water using chlorine

2022
109. Compared to a fertilizer tank (bypass tank) for fertigation, the venturi injector is generally preferred for its:
(A) Operation without requiring any significant operating pressure differential
(B) Utilization of highly complex mechanisms with multiple moving components
(C) Exclusive compatibility with highly insoluble granular fertilizers
(D) Maintenance of a constant fertilizer concentration in the water flow

2025
110. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Urea is widely used as a nitrogen source in fertigation.

Reason (R): It is highly soluble in water and does not cause chemical precipitation or emitter clogging.

In the light of the above statements, choose the

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(D) 80 mm

2005
149. Which of the following pairs is INCORRECT regarding the critical growth stage for moisture stress sensitivity?
(A) Sugarcane : Formative stage
(B) Sorghum : Maturity and harvest stage
(C) Potato : Tuber initiation and development
(D) Soybean : Pod filling stage

2025
150. A severe moisture deficit during the silking stage of maize typically causes:
(A) Immediate lodging and mechanical failure of the plant stalk
(B) Massive increase in the initiation of secondary tillers
(C) Poor fertilization resulting in completely barren cobs
(D) Highly accelerated leaf elongation and canopy expansion

2016
151. Which soil physical property is crucial for designing the emitter spacing in a drip irrigation system?
(A) Soil surface color and visual hue
(B) Soil chemical cation exchange capacity
(C) Soil organic matter and carbon content
(D) Soil hydraulic and capillary properties

2012
152. For scheduling irrigation in a large-scale commercial orchard, which combination of tools is most appropriate and practical?
(A) Moisture sensors paired with weather-based ET models
(B) Direct gravimetric sampling conducted exclusively in fields
(C) Hand feel and appearance visual assessments of soil cores
(D) High-resolution satellite imagery lacking any ground truth

2002
153. The "Available Water Capacity" (AWC) of soil is the moisture held between:
(A) Saturation and Permanent Wilting Point
(B) Field Capacity and Permanent Wilting Point
(C) Saturation and Field Capacity
(D) Field Capacity and Hygroscopic Coefficient

2023
154. Which of the following safety components is mandatory in a chemigation system to prevent the backflow of agricultural chemicals into the irrigation water source?
(A) Pressure relief valve
(B) Vacuum relief valve
(C) Non-return check valve and vacuum breaker assembly
(D) Pressure-compensating emitter bypass

2001
155. Granular matrix sensors (like Watermark sensors) estimate soil moisture based on which operating principle?
(A) Electrical resistance variations
(B) Thermal dissipation patterns
(C) Dielectric constant alterations
(D) Moderated neutron scattering

2007
156. Which of the following statements is correct regarding subsurface drainage?
(A) Subsurface drainage systems completely eliminate any crop irrigation needs
(B) It relies completely on incoming solar radiation to drive water evaporation
(C) It lowers water tables artificially to provide an aerated root zone
(D) It is exclusively implemented in sandy well-drained desert soils

2014
157. Implementing water pricing based on volumetric measurement is most likely to encourage farmers to:
(A) Increase the cultivation of high-water-demand crops
(B) Over-irrigate fields to maximize water utility
(C) Abandon intensive commercial agricultural activities
(D) Adopt water-saving technologies and improve irrigation efficiency

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2006
158. A heavy pre-sowing irrigation (locally called 'rauni' or 'palewa' in India) is primarily applied to:
(A) Leach highly soluble nutrient elements deep down into the lower profile
(B) Cool the localized micro-climate and ambient air temperatures
(C) Provide soil moisture for uniform seed germination and seedling growth
(D) Destroy dormant weed seeds in the surface soil through thermal shock

be continuously withdrawn without causing adverse impacts like severe depletion
(B) The maximum pumping rate possible with modern pumps
(C) The amount of water available in the aquifer storage
(D) The amount of water that can be withdrawn for short periods regardless of recharge

2011
140. Which of the following pairs correctly associates an irrigation institution with its primary function?
(A) Central Water Commission (CWC) : Industrial manufacturing of drip irrigation pipes
(B) Command Area Development Authority (CADA) : Automated meteorological forecasting
(C) Water User Association (WUA) : Operation of micro-level canal distribution networks
(D) Ministry of Jal Shakti : Regulation of international import-export trade licenses

2022
141. In historically arid regions, the introduction of canal irrigation without adequate drainage typically leads to:
(A) Significant increase in wind erosion from surface-wetted soils
(B) Complete desalinization of deep groundwater aquifer reserves
(C) Permanent reduction in relative atmospheric humidity levels
(D) Rapid water table rise, eventually leading to waterlogging

2008
142. Which of the following is an agronomic method to mitigate the adverse effects of saline irrigation water?
(A) Implementing deep tillage and moldboard plowing
(B) Installing artificial subsurface drainage tile networks
(C) Selecting highly salt-tolerant crop variety for planting
(D) Constructing impermeable concrete canal linings to stop seepage

2009
143. If a soil has a field capacity of 25% (by weight), a permanent wilting point of 10%, and a bulk density of 1.4 g/cm^3, what is the depth of available water in a 1-meter root zone?
(A) 100 mm
(B) 150 mm
(C) 210 mm
(D) 350 mm

2008
144. Deep-rooted crops like safflower and cotton:
(A) Require highly frequent, shallow, daily sprinkler irrigation events
(B) Are completely immune to moisture deficit stress across all growth stages
(C) Exhibit identical water extraction profiles to surface-creeping grasses
(D) Can tap deeper soil moisture, requiring less frequent irrigation cycles

2006
145. The "hydraulic gradient" in groundwater flow is defined as the:
(A) The change in hydraulic head per unit distance of flow
(B) The ratio of horizontal distance to vertical elevation
(C) The volume of water passing through a unit cross-section
(D) The intrinsic permeability of the porous medium

2017
146. In border irrigation, the maximum allowable non-erosive stream size primarily depends on:
(A) Crop height
(B) Air temperature
(C) Soil texture and land slope
(D) The type of pump used

2022
147. If an irrigation channel is designed with an extremely flat slope:
(A) Flow velocity will be low, leading to potential silt deposition
(B) Flow velocity will be high, leading to severe channel bed scouring
(C) Water in the channel will run dry very rapidly
(D) Evaporative water losses in the canal will drop to zero percent

2019
148. Using the IW/CPE approach, if 50 mm of irrigation is to be applied at an IW/CPE ratio of 0.8, at what cumulative pan evaporation (CPE) value should the irrigation be scheduled?
(A) 40 mm
(B) 50 mm
(C) 62.5 mm

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2013
170. Which of the following is NOT a factor affecting the water requirements of a crop?
(A) Climate (temperature, radiation, wind)
(B) Subsurface geological mineral color
(C) Crop characteristics (variety, growth stage)
(D) Soil characteristics (texture, structure, depth)

2002
171. In irrigation engineering, the 'Duty of Water' represents:
(A) The irrigable land area per unit of continuous water flow over a crop season
(B) The specific volumetric quantity of water required to irrigate a unit field
(C) The strict legal and fiscal obligation of farm owners to pay canal taxes
(D) The absolute hydraulic performance and lining efficiency of a distribution canal

2010
172. The 'Base Period' of a crop is defined as the:
(A) Complete agronomic crop growing time span from sowing to harvest
(B) Specific vegetative stage during which peak biomass is produced
(C) Time between the first pre-sowing irrigation and final watering
(D) Cumulative hours of operation recorded for the irrigation pump

2021
173. The much higher water requirement (Delta) of rice compared to wheat is primarily due to the:
(A) Deep and extensive root development patterns unique to rice crops
(B) Colder ambient climate conditions during typical rice cultivation
(C) Higher biological transpiration rate of wheat under equivalent conditions
(D) Requirement of continuous standing water for weed control and growth

2016
174. The relationship between Duty (D in ha/cumec), Delta (Δ in meters), and Base Period (B in days) is given by:
(A) $\Delta = \frac{8.64 \times D}{B}$
(B) $D = \frac{8.64 \times \Delta}{B}$
(C) $\Delta = \frac{8.64 \times B}{D}$
(D) $B = \frac{8.64 \times \Delta}{D}$

2004
175. Based on the field water balance equation, if precipitation = 100 mm, irrigation = 50 mm, evapotranspiration (ET) = 120 mm, runoff = 10 mm, and deep percolation = 15 mm, what is the change in soil moisture storage?
(A) - 5 mm
(B) 0 mm
(C) + 5 mm
(D) + 20 mm

2015
176. Which of the following statements concerning waterlogging is INCORRECT?
(A) It drastically reduces oxygen availability in the root zone.
(B) It can lead to the accumulation of toxic compounds like hydrogen sulfide.
(C) It impairs the absorption of nutrients by roots.
(D) It enhances the activity of aerobic soil microorganisms.

2001
177. A sodic (alkali) soil is characterized by:
(A) Low soluble salts and an exchangeable sodium percentage (ESP) above 15%
(B) High soluble salts and an exchangeable sodium percentage (ESP) below 15%
(C) High organic matter content and an extremely low soil pH
(D) Extremely low soil pH with high aluminum toxicity

2013
178. Which of the following statements is correct regarding the reclamation of saline and sodic soils?
(A) Both soil types can be reclaimed effectively using simple clean water leaching cycles
(B) Saline soils require chemical gypsum application, whereas sodic soils do not need any
(C) Sodic soils require gypsum application followed by leaching, while saline soils require only leaching
(D) Neither degraded soil category can ever be successfully restored or reclaimed

2007
179. Participatory Irrigation Management (PIM) primarily aims to:
(A) Institutionalize farmer participation in the operation and maintenance of irrigation systems

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2003

159. Which of the following is NOT an objective of Command Area Development (CAD)?
(A) Construction of field channels and drains
(B) Building massive new multipurpose dams
(C) Land shaping and leveling
(D) Implementation of warabandi

2004

160. Compared to border irrigation, furrow irrigation is particularly advantageous for:
(A) Small, closely spaced grains like wheat
(B) Forage crops like alfalfa
(C) Flooded rice cultivation
(D) Row crops like cotton, maize, and potato

2014

161. Which of the following irrigation methods is best suited for undulating topography where land leveling is difficult or uneconomical?
(A) Sprinkler or drip irrigation
(B) Check basin
(C) Border strip
(D) Large-scale flooding

2019

162. The "osmotic potential" of soil water is defined as the:
(A) Physical pressure exerted by soil matrix forces
(B) Potential energy from elevation above references
(C) Energy reduction from dissolved solute particles
(D) Hydrostatic pressure from a shallow water table

2017

163. In agricultural water management, the term "consumptive use" is synonymous with:
(A) Evapotranspiration
(B) Infiltration
(C) Percolation
(D) Effective rainfall

2010

164. The Blaney-Criddle formula for calculating consumptive use relies on a crop constant (K) and which of the following primary variables?
(A) Ambient surface soil temperature profile
(B) Average wind speed and solar net radiation
(C) Fluctuating barometric atmospheric pressure
(D) Monthly mean temperature and daytime hours

2005

165. Which of the following tests is used to evaluate the water distribution uniformity of a sprinkler irrigation system?
(A) Gravimetric field soil sampling
(B) Catch can tests of uniformity
(C) Automated tensiometer probes
(D) Chemical water quality testing

2008

166. Which of the following empirical methods for calculating reference evapotranspiration is considered the most accurate and physically based by the FAO?
(A) Hargreaves
(B) Thornthwaite
(C) FAO-56 Penman-Monteith
(D) Blaney-Criddle

2008

167. Excessive accumulation of specific ions (such as sodium) in plant tissues causes toxicity primarily due to:
(A) Rapid stimulation of net photosynthetic rates
(B) Structural strengthening of vegetative cell walls
(C) Chemical enhancement of essential potassium uptake
(D) Interference with cellular enzymes and metabolism

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2023

168. Which of the following pairs is correct regarding irrigation water measurement devices and their functions?
(A) Cut-throat flume : Measures open channel water discharge
(B) Current meter : Measures depth profiles of local rivers
(C) Tensiometer : Measures canal water flow velocities
(D) Piezometer : Measures soil volumetric moisture percentages

2003

169. In hydrology, what does the term 'time of concentration' represent?
(A) The physical time duration required for surface rainfall to evaporate
(B) The travel time from the furthest point in the catchment to the outlet
(C) The total time duration required for runoff water to infiltrate soil
(D) The specific diurnal time window when crop transpiration is highest

(D) Rainwater harvesting on private property sites

2024

189. The Inter-State River Water Disputes Act, which provides for the adjudication of disputes relating to waters of inter-state rivers, was enacted in:
(A) 1947
(B) 1956
(C) 1990
(D) 2005

2023

190. In agriculture, 'water productivity' is defined as the:
(A) Absolute total biological yield of crops produced per hectare
(B) Direct financial cost incurred from irrigating one field hectare
(C) Crop yield produced per unit volume of water consumed
(D) Cumulative volume of water actually transpired by active crops

2001

191. If a state policy heavily subsidizes solar water pumps without restricting groundwater extraction, it is highly likely that:
(A) Regional groundwater levels will steadily and naturally stabilize.
(B) Groundwater depletion will accelerate due to zero marginal pumping costs.
(C) Field irrigation water efficiency values will naturally increase.
(D) Soil salinization processes will significantly and rapidly drop.

2005

192. Which legal doctrine is increasingly advocated for sustainable groundwater management, shifting away from absolute land-linked ownership?
(A) Rule of Capture
(B) Absolute Dominion
(C) Prior Appropriation
(D) Public Trust Doctrine

2011

193. The Coriolis force, which influences large-scale hydrological and atmospheric phenomena, arises from:
(A) The Earth's rotation
(B) Solar radiation gradients
(C) Lunar gravitational pull
(D) Geothermal heating

2016

194. Which of the following represents the major bottleneck in achieving the target efficiency in the Command Area Development (CAD) program?
(A) General lack of high-resolution satellite remote sensing imagery
(B) Widespread unavailability of advanced high-yielding crop seeds
(C) Poor maintenance of tertiary channels and field channels
(D) Severe regional shortages of heavy agricultural tractors and tools

2001

195. Compared to conventional surface irrigation, the nutrient use efficiency in drip fertigation is typically:
(A) Higher due to synchronization with crop demand
(B) Lower due to concentrated localized applications
(C) Completely identical to conventional methods
(D) Highly unpredictable and fluctuating seasonally

2019

196. In fertigation, 'fertilizer compatibility' refers to:
(A) The physical ability of fertilizers to be easily transported by trucks
(B) The chemical effect of active fertilizer compounds on local soil pH
(C) The official legal and regulatory approval status of commercial brands
(D) The ability to mix multiple fertilizers without forming insoluble precipitates

2009

197. Mixing calcium nitrate and ammonium sulfate in a single concentrated fertigation tank causes:
(A) Highly enhanced nitrogen gas volatilization losses
(B) Insoluble calcium sulfate precipitation and clogging
(C) A highly rapid physical drop in system water temperature
(D) The immediate chemical formation of pure nitrate crystals

2014

198. Applying phosphorus through a micro-irrigation system usually requires an acidic environment to prevent precipitation. Which acid is most commonly injected alongside P-fertilizers to lower the pH?

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fluid mechanics equations, the volumetric flow rate through a ninety-degree V-notch weir is proportional to the measured head raised to the power of five-halves, ensuring accurate measurement of low discharges.

63. (B) Drip emitter or low-yield well pipe
Volumetric measurement using a container of known volume and a stopwatch is highly accurate but limited by physical capacity. It is most practical for measuring small, localized discharges, such as individual drip emitter outflows or low-yield well discharge pipes, where the entire flow can be easily captured and timed.

64. (D) Excessive deep percolation near the inlet and dry far end
Sandy soils possess high infiltration rates and high hydraulic conductivity. When check basin irrigation is used, water infiltrates rapidly as it moves across the basin. This slow advance causes water to pond near the inlet, leading to excessive deep percolation losses, while the far end of the basin remains dry.

65. (A) Advance phase → Storage phase → Depletion phase → Recession phase
Furrow irrigation progress follows a distinct chronological sequence. The process begins with the advance phase as water moves down the dry furrow. Once water reaches the end, the storage phase begins, followed by the depletion phase after the inflow is shut off. Finally, the recession phase occurs as water drains.

66. (C) Flat slopes, clayey soils, and large streams
Longer border strips require conditions that prevent rapid infiltration and maintain continuous water advance. Flat slopes, clayey soils with low infiltration rates, and large stream sizes ensure water flows smoothly across the entire length. This minimizes deep percolation losses at the upper end and achieves uniform water distribution.

67. (A) Center-pivot irrigation
Center-pivot irrigation is a highly mechanized, pressurized overhead system that distributes water through rotating sprinklers mounted on wheeled towers. It is classified under sprinkler irrigation systems. In contrast, corrugations, border basins, and surge flows are gravity-fed surface irrigation methods where water moves directly over the soil surface.

68. (D) Time of cutoff divided by total advance time
The cutoff ratio in surface irrigation is a design parameter used to optimize application efficiency. It is defined as the ratio of the time of cutoff to the total time required for the water front to advance to the end of the field. Managing this ratio helps minimize tailwater runoff and deep percolation.

69. (B) It applies water intermittently in cycles to reduce infiltration.
Surge irrigation applies water to furrows in intermittent on-and-off cycles rather than continuous flow. During the off period, the soil surface drains and seals slightly due to particle rearrangement and air entrapment. This reduces soil infiltration capacity, allowing the next water surge to advance faster and more uniformly down the furrow.

70. (B) III, II, IV, I
In a drip irrigation system, water flows sequentially from the source through various components to ensure clean delivery. Water first enters the sand filter to remove suspended particles. It then travels through the mainline, flows into the sub-main and laterals, and is finally discharged slowly into the soil via emitters.

71. (D) Basic infiltration rate
Sprinkler systems must apply water at a rate that the soil can absorb. If the water application rate exceeds the basic infiltration rate of the soil, excess water cannot infiltrate and begins to accumulate on the surface. This leads to surface runoff, localized ponding, and severe soil erosion, reducing overall system efficiency.

72. (A) Drip fertigation
Drip fertigation integrates pressurized micro-irrigation with soluble fertilizer application. This system delivers water and essential nutrients directly to the active root zone of the plant in precise amounts. This localized application minimizes nutrient leaching, reduces weed growth, and optimizes both water and fertilizer use efficiency throughout the growing season.

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73. (B) Subsurface porous-wall irrigation
Pitcher irrigation utilizes unglazed, porous clay pots buried up to their necks in the soil. When filled with water, moisture gradually seeps through the porous clay walls directly into the surrounding soil, driven by the soil moisture

(D) Lower in fertigation due to immediate incorporation

2012

209. The injection rate of a proportional fertigation pump is directly tied to the:
(A) Water flow rate of the main pipeline
(B) Local atmospheric barometric pressure levels
(C) Ambient temperature of the surrounding air
(D) Physical specific gravity of fertilizers

2021

210. In micro-irrigation scheduling, fertigation is typically injected during which phase of the irrigation cycle?
(A) In the early phase, before water enters pipelines
(B) Only during the first five minutes of system startup
(C) In the middle phase, followed by a clear water flush
(D) During the final two minutes before shutting down

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21. (B) It holds water but yields it too slowly for use.
Porosity determines the total volume of water an aquifer can store, while permeability dictates how easily water flows through the pore spaces. An aquifer with high porosity but extremely low permeability, such as clay, can store vast quantities of water but cannot transmit it efficiently, making groundwater extraction unviable for active pumping.

22. (C) Cauvery
The Grand Anicut, also known as the Kallanai, is an ancient water-diversion structure built across the Cauvery River in Tamil Nadu. Constructed during the second century by the Chola king Karikalan, it diverted river water into irrigation canals. It remains one of the oldest operational water-regulator structures in the world.

23. (D) Altering natural flow and sediment trapping
Large-scale river valley projects store immense volumes of water, significantly altering the downstream seasonal hydrograph. The reservoirs act as physical traps for sediments, preventing nutrient-rich silt from reaching downstream floodplains and deltas. This alteration disrupts aquatic ecosystems, modifies river channel morphology, and reduces fertile soil deposition in agricultural areas.

24. (A) Johad Water Harvesting System
Multi-purpose river valley projects are large-scale state interventions designed for flood control, irrigation, power generation, and drinking water. In contrast, a Johad is a traditional, community-managed rainwater harvesting structure. These small-scale earthen check dams are built in dry regions to capture runoff and recharge local groundwater tables.

25. (B) P-3, Q-4, R-1, S-2
Major river valley projects are built on specific rivers. The Bhakra-Nangal project is constructed on the Sutlej River. The Hirakud Dam is situated across the Mahanadi River. The Sardar Sarovar Dam is located on the Narmada River. Lastly, the Nagarjuna Sagar Dam regulates the flow of the Krishna River, establishing this specific combination.

26. (B) Culturable Command Area (CCA)
In India, irrigation projects are classified based on the Culturable Command Area, which is the land area that can be physically irrigated and is fit for cultivation. This parameter acts as the primary regulatory threshold for categorizing projects into major, medium, or minor schemes, rather than using financial costs or dam height.

27. (B) 2,000 to 10,000 hectares
The Planning Commission of India classifies irrigation schemes according to the size of their Culturable Command Area. Minor projects cover areas up to two thousand hectares. Medium irrigation projects serve lands spanning between two thousand and ten thousand hectares. Schemes exceeding ten thousand hectares are classified as major irrigation projects.

28. (C) Famine Commission of 1880
The Famine Commission of 1880 highlighted the critical need for protective irrigation systems to safeguard agriculture against recurrent droughts. It recommended the rapid construction of canals in vulnerable regions to ensure crop survival rather than maximizing revenue. This policy shift laid the foundation for modern state-sponsored irrigation networks in India.

29. (D) Field soil moisture availability
Actual evapotranspiration represents the real amount of water lost from the soil and crop system under ambient conditions. Unlike potential evapotranspiration, which assumes unlimited water supply, actual evapotranspiration is highly constrained by the current moisture content in the root zone. If the soil is dry, water loss is significantly restricted.

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30. (A) Grand Anicut → Western Yamuna Canal → Bhakra Dam
The historical development of irrigation structures spans centuries. The Grand Anicut was constructed during the ancient Chola period in the second century. The Western Yamuna Canal was originally built in the fourteenth century and renovated during the British colonial era. The modern Bhakra Dam was completed post-independence in nineteen sixty-three.

31. (B) ET_0 is defined for a well-watered hypothetical grass crop.
Reference crop evapotranspiration represents the rate of water loss from a standardized, well-watered hypothetical grass surface with specific height, albedo, and active growth characteristics. While potential evapotranspiration is a broader

and permanent wilting point, not saturation. Therefore, assertions indicating uniform crop wilting points and saturation-based capacity calculations are scientifically inaccurate.

11. (A) Hygroscopic coefficient : -15 bar
The hygroscopic coefficient represents the soil moisture content when the soil is in equilibrium with an atmosphere of high relative humidity. This state occurs under extreme suction, specifically at a tension of approximately thirty-one bars. Conversely, fifteen bars of tension corresponds to the permanent wilting point, making the associated pairing incorrect.

12. (C) Silt loam
Silt loam soils possess a favorable balance of macropores and micropores, allowing them to store high amounts of water while releasing it easily to plants. Coarse soils drain too quickly, while heavy clay soils hold water very tightly due to high matric suction, which reduces the actual volume of water available to crops.

13. (D) Unavailable water
Soil moisture held at tensions between fifteen and thirty-one atmospheres is bound too tightly by matric forces for plants to extract. The permanent wilting point occurs at fifteen atmospheres, marking the limit of available water. Any water retained at greater tensions is functionally unavailable to agricultural crops, leading to irreversible wilting.

14. (C) Shrinkage limit
The shrinkage limit is the specific moisture content below which any further loss of water does not cause a decrease in the total volume of the soil mass. At this threshold, the soil transitions from a semi-solid to a solid state, and air begins to enter the pores, causing mass wetness to decline independently.

15. (B) I, III and V
Precipitation includes all forms of atmospheric water reaching the ground. Transpiration is the biological release of water vapor by plants. Percolation is the downward flow of water through soil. Interception loss evaporates before reaching groundwater, and surface runoff can occur even when infiltration capacity is positive if rainfall intensity exceeds it.

16. (D) Streamflow derived from groundwater seepage
Baseflow represents the sustained portion of stream discharge that flows even during prolonged dry periods without rainfall. This water source originates from shallow and deep groundwater reserves that slowly seep through the channel banks and bed. It maintains continuous river flow and is distinct from direct surface runoff generated during storms.

17. (A) $P - R - G - E - T = \Delta S$
The water balance equation is a mathematical expression of the conservation of mass within a catchment. Precipitation represents the primary input. The outputs include surface runoff, groundwater recharge, evaporation, and transpiration. The difference between these inputs and outputs equals the net change in soil water storage over a specified time interval.

18. (C) Average annual precipitation : 4000 BCM
According to official estimates from the Central Water Commission, India receives an average annual precipitation of approximately four thousand billion cubic meters. This total input is distributed across rainfall and snowfall. Out of this vast volume, only a fraction is converted into realizable surface water and replenishable groundwater resources due to evaporation and runoff.

19. (A) South-West Monsoon
The South-West Monsoon is the primary meteorological season in India, spanning from June to September. This system delivers nearly seventy-five percent of the country's total annual rainfall. It is critical for replenishing reservoirs, recharging groundwater aquifers, and supporting rainfed agriculture, making it the most significant hydrological event across the subcontinent.

20. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
North-Western India faces severe groundwater depletion due to intensive agriculture. The cultivation of water-intensive crops like paddy in semi-arid zones requires massive volumes of water. This practice is facilitated by heavily subsidized electricity, which encourages continuous pumping of deep aquifers, causing groundwater levels to fall at an alarming rate over recent decades.

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(A) Acetic acid
(B) Hydrofluoric acid
(C) Sulfuric or Phosphoric acid
(D) Citric acid

2015
199. Potassium fertilizers, such as potassium chloride (Muriate of Potash), are generally:
(A) Highly insoluble in cold water temperatures
(B) Chemically toxic to polymer drip system tubes
(C) Completely unsuitable for agricultural systems
(D) Highly soluble and suitable for fertigation

2005
200. A venturi injector operates based on which of the following fluid mechanics principles?
(A) Bernoulli's principle of pressure drop
(B) Archimedes' principle of fluid buoyancy
(C) Pascal's law of pressure transmission
(D) Newton's third law of reactive forces

2009
201. Which of the following pairs is INCORRECT regarding fertigation equipment and its primary function?
(A) Fertilizer tank : Creates a pressure differential to slowly bypass water through solid/liquid fertilizer
(B) Sand media filter : Primarily designed to dissolve solid fertilizers
(C) Venturi injector : Uses kinetic energy of water to draw in fertilizer solution
(D) Proportional injection pump : Powered directly by the water flow to inject precise volumetric ratios

2004
202. In fertigation, 'pulsing' or split application is primarily used to reduce:
(A) Evaporation losses from soil surfaces
(B) Nutrient leaching past active root zones
(C) Overall purchase cost of raw fertilizer
(D) Mechanical wear and tear of water pumps

2014
203. Which of the following is NOT a fundamental prerequisite for successful fertigation?
(A) Completely insoluble granular fertilizers
(B) A properly designed and functioning micro-irrigation system
(C) Good quality irrigation water
(D) Knowledge of the crop's stage-wise nutrient requirements

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2017
204. Chlorination of micro-irrigation systems is typically performed to:
(A) Provide chloride macronutrients to field plants
(B) Increase the overall pH value of agricultural soils
(C) Prevent biological clogging in drip lines
(D) Precipitate calcium carbonate minerals out of water

2025
205. If a water-soluble fertilizer contains 20% nitrogen and a farmer needs to apply 10 kg of actual N per hectare per fertigation cycle on a 2-hectare plot, how much total fertilizer product must be dissolved in the tank?
(A) 20 kg
(B) 50 kg
(C) 100 kg
(D) 200 kg

2004
206. Due to the high mobility of nitrate (NO_3^-) in soil, applying all required nitrogen in a single massive dose at the beginning of the season is:
(A) Highly efficient and beneficial for seasonal root growth
(B) The recommended management practice for commercial orchard crops
(C) Inefficient, leading to leaching losses and groundwater pollution
(D) Necessary to prevent biological clogging in drip emitters

2018
207. In soil science, 'nutrient mobility' dictates:
(A) The average physical flow speed of water in channels
(B) How easily a nutrient moves with water and leaches
(C) The visual color profile and organic content of soil
(D) The technical material type of piping system required

2015
208. Compared to surface broadcasting of urea followed by flooding, ammonia volatilization losses from drip fertigation of urea are generally:
(A) Significantly higher under modern fertigation setups
(B) Exactly identical across both application methods
(C) Reduced to absolute zero under continuous flooding

concept representing maximum possible water loss under prevailing climate, reference evapotranspiration provides a highly consistent baseline for agricultural crop water calculations.

32. (D) Crop ET (ET_c) to Reference ET (ET_0)
The crop coefficient is a dimensionless ratio that relates the specific water demand of a crop to that of a reference grass under identical climate conditions. It integrates plant physiological characteristics, leaf area development, and surface resistance, allowing engineers and scientists to calculate the actual crop evapotranspiration from reference evapotranspiration values.

33. (A) Mass transfer and vapor transport
The aerodynamic method calculates evapotranspiration based on the physical transport of water vapor from the evaporating surface into the atmosphere. This approach relies on mass transfer principles, focusing on factors like wind speed gradients and vapor pressure deficits. It models how turbulent air movement carries moisture away from the crop canopy.

34. (A) Initial stage
During the initial growth stage, the crop canopy is small, and leaf area index is low. Consequently, transpiration is minimal, and overall water loss is dominated by soil evaporation. Since the crop has not developed substantial leaf area to intercept light and transpire, the total evapotranspiration rate is at its lowest level.

35. (B) II, IV, I, III
The standard FAO-56 methodology defines the chronological sequence of crop development for water resource calculations. The growth cycle begins with the initial stage, followed by the crop development stage. Subsequently, the crop enters the mid-season stage, where leaf area is maximized, and concludes with the late-season stage leading to harvest maturity.

36. (C) 6.0 mm/day
Crop evapotranspiration under optimal, non-limiting moisture conditions is calculated by multiplying the reference crop evapotranspiration by the specific crop coefficient. Multiplying the daily reference evapotranspiration value of five millimeters by the mid-season crop coefficient of one point two yields a daily water requirement of exactly six point zero millimeters.

37. (B) It is only applicable for estimating evaporation from open water bodies.
The Penman-Monteith equation is a comprehensive, physically-based model designed to estimate evapotranspiration from vegetated surfaces. It is not restricted to open water bodies, as it incorporates surface and canopy resistance parameters. This makes it highly versatile and widely recognized as the global standard for calculating reference crop evapotranspiration under diverse climates.

38. (C) Stomatal control of transpiration
Canopy resistance represents the collective biological resistance of all leaves to water vapor transport. This parameter primarily accounts for the physiological role of stomata, which open and close in response to light, humidity, and water stress. By regulating stomatal aperture, the crop directly controls transpiration rates and maintains internal water balance.

39. (D) Variable wind and advective heat
The Blaney-Criddle method is a simplified temperature-based approach that does not directly account for wind speed or relative humidity. In regions characterized by high advective energy, dry winds, or frequent microclimate changes, the omission of aerodynamic components causes significant estimation errors, making the method highly inaccurate compared to comprehensive energy balance models.

40. (A) III only
The Blaney-Criddle method relies primarily on mean temperature and percentage of daytime hours to estimate potential water loss, rather than wind speed and relative humidity. Conversely, the Thornthwaite and Hargreaves formulations are correctly associated with their primary inputs of air temperature and solar radiation, rendering the third combination incorrect.

41. (B) Water used for metabolic processes
Consumptive use represents the total amount of water utilized by a crop during its lifecycle. This encompasses the water lost through soil evaporation and plant transpiration, combined with the small fraction of water retained within the plant tissues or consumed for vital metabolic processes, photosynthesis, and vegetative growth.

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ANSWERS

1. (A) Matric potential
Soil water potential components determine water movement and retention. In unsaturated soils, matric potential is the dominant component holding water against gravity. This force arises from the adsorption of water to soil solid surfaces and capillary forces within the soil pores. It is highly negative in dry soils, significantly restricting water availability and movement.

2. (C) Hydraulic gradient
Darcy's Law mathematically describes the flow of fluid through a porous medium like soil. It states that the rate of water flow is directly proportional to the hydraulic gradient. This gradient represents the change in total hydraulic head per unit distance along the flow path, driving water from high to low potential.

3. (A) Initial high rate decreasing to a constant
During a continuous rainfall event, the infiltration rate starts high due to dry soil surfaces and high matric suction gradients. As the soil becomes saturated, these suction gradients decrease and clay minerals swell. Eventually, the rate stabilizes to a constant value, which is primarily governed by the saturated hydraulic conductivity of the soil.

4. (D) It is held by surface tension in capillary pores and is largely available to plants.
Capillary water is the liquid held in micropores by cohesive and adhesive forces against gravity. This water form exists as films around soil particles and within small pores. It constitutes the primary source of moisture utilized by crops, as it remains readily extractable within the range of normal plant physiological suction.

5. (B) I and II
Matric potential represents the binding forces of the soil matrix and is consistently negative in unsaturated soils due to capillary and adhesive actions. Gravitational potential increases with height relative to a chosen reference plane, making it positive above that plane. Osmotic potential is only significant in saline soils and does not dominate mass flow.

6. (C) Infiltration rate lower than application rate
Water pooling occurs when the rate of water application exceeds the ability of the soil to absorb it. Fine-textured clay soils possess low saturated hydraulic conductivity and low basic infiltration rates. When irrigation water is applied faster than this infiltration threshold, excess water accumulates on the surface, resulting in immediate ponding.

7. (D) Higher water content during drying than during wetting
Hysteresis describes the relationship where soil water content is higher during desorption than during sorption at the same matric suction. This lag occurs due to the ink-bottle effect of soil pores, contact angle differences, entrapped air, and swelling-shrinking processes. Consequently, a drying soil retains more moisture at a given tension than a wetting soil.

8. (A) Sand has higher conductivity; clay has higher porosity.
Sand has larger, continuous macropores that allow rapid water movement, leading to high saturated hydraulic conductivity. In contrast, clay consists of numerous micro-sized pores that provide a much greater total pore volume, resulting in higher overall porosity. However, these tiny pores restrict water movement, yielding lower hydraulic conductivity than sandy soils.

9. (B) 2.53
The pF scale represents the logarithm of soil moisture tension expressed in centimeters of water column height. Field capacity generally corresponds to a suction of approximately one-third of a bar, equivalent to about three hundred and forty centimeters of water head. Taking the logarithm of this head value yields a pF value of approximately two point fifty-three.

10. (B) I and II
Permanent wilting point varies depending on plant species and environmental conditions, rather than occurring uniformly at a single value. Available water capacity is defined as the moisture retained between field capacity

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the plants from water deficit while optimizing irrigation application intervals.

53. (B) Irrigation Water applied to Cumulative Pan Evaporation
The IW/CPE ratio is a climatological approach for scheduling irrigation. It relates a fixed depth of irrigation water applied to the cumulative evaporation recorded from a standard Class-A pan since the last irrigation. This method aligns irrigation frequency with atmospheric demand, ensuring water is applied when crop consumption matches a set threshold.

54. (C) Irrigation depth equals cumulative evaporation
An IW/CPE ratio of one point zero indicates that the depth of irrigation water applied to the field is exactly equal to the cumulative pan evaporation recorded. This balanced ratio ensures that the water extracted from the soil profile by evapotranspiration is fully replenished during the irrigation event, keeping soil moisture stable.

55. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Pan evaporation rates exceed reference crop evapotranspiration because open water bodies absorb more radiation and have less aerodynamic resistance than a green crop. The pan coefficient is used to scale down pan readings, adjusting for these physical differences in albedo, roughness, and heat storage, which ensures accurate crop water use estimates.

56. (A) Relative crop water stress based on canopy-to-air temperature differences and vapor pressure deficit
The Crop Water Stress Index is a normalized indicator of plant water status calculated using canopy temperature. Under moisture stress, plants close their stomata, reducing transpirational cooling and raising canopy temperature above ambient air temperature. The index quantifies this temperature difference relative to dry and wet reference baselines under prevailing vapor pressure deficits.

57. (B) Stomatal closure is restricting transpirational cooling.
Transpiration cools leaves by dissipating latent heat during evaporation. When soil water is depleted, plants close their stomata to conserve moisture. This physiological response restricts transpiration, causing sensible heat to accumulate on the leaves. Consequently, the canopy temperature rises significantly above the ambient air temperature, indicating severe moisture stress.

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58. (B) Sap flow sensor installation
Sap flow sensors provide a continuous, non-destructive, and real-time measurement of water movement through the plant stem. Unlike destructive methods like leaf water potential or gravimetric sampling, sap flow sensors use heat dissipation or balance techniques to monitor active transpiration, offering precise insights into crop water status without damaging plant tissues.

59. (A) Early visible wilting symptoms relative to main crop
Indicator plants are sensitive species sown alongside the commercial crop to assist in irrigation scheduling. These plants possess high transpiration rates or shallow root systems, causing them to exhibit visible wilting symptoms before the main crop experiences stress. This serves as an early warning for farmers to apply water.

60. (C) P-3, Q-1, R-2, S-4
Flow measurement structures have unique operational characteristics. The V-notch weir is highly accurate for measuring low discharges. The Parshall flume operates efficiently under submerged conditions with minimal head loss. The Dethridge meter uses a rotating wheel to record volume. An orifice plate restricts flow, measuring discharge under pressure through an opening.

61. (D) It is self-cleaning and handles high sediment loads.
Parshall flumes feature a converging section, a throat, and a diverging floor, which increases water velocity through the structure. This high-velocity flow prevents the deposition of silt and debris within the flume. Consequently, it remains self-cleaning and highly reliable in unlined earthen canals carrying heavy sediment loads.

62. (D) $H^{\frac{5}{2}}$
The discharge over a triangular V-notch weir is mathematically determined by the head of water flowing over the crest. According to standard

42. (B) Rainfall stored in the root zone for crop use
Effective rainfall refers to the portion of total precipitation that is directly stored in the root zone and becomes available to meet the crop water requirement. It excludes losses due to surface runoff, deep percolation below the root zone, and immediate evaporation from the soil surface prior to infiltration.

43. (A) The stage where water stress causes maximum yield loss.
The critical growth stage is a physiologically sensitive phase during which moisture deficiency severely impairs plant development and reproductive structures. If water stress occurs during this specific period, it results in the most substantial and irreversible decline in final crop yield, making irrigation scheduling during this phase absolutely essential for farmers.

44. (C) Wheat is sensitive at CRI; rice is sensitive at panicle initiation.
Wheat and rice exhibit distinct physiological responses to moisture timing. For wheat, the crown root initiation stage is highly sensitive, as stress here severely limits tiller development. For rice, the panicle initiation phase is critical because moisture deficit directly reduces the number of spikelets per panicle, significantly diminishing final grain yields.

45. (D) I, II and III
Maize, groundnut, and chickpea require adequate moisture during flowering, pegging, and pod development to ensure optimal yields. In contrast, sugarcane requires a dry period during its maturity and ripening stage to promote sugar accumulation and concentration in the stalks. Applying irrigation during ripening decreases sucrose content, making the fourth combination incorrect.

46. (C) Flowering and seed development
Oilseed crops are highly susceptible to moisture deficits during flowering and seed formation. Stress at this stage reduces fertilization success, increases flower abortion, and restricts the translocation of assimilates to the developing seeds. This limits seed size, weight, and overall oil content, leading to drastic drops in oil yield.

47. (B) Crown Root Initiation (CRI)
Crown root initiation occurs approximately twenty-one days after sowing and represents the most critical growth phase for wheat. If water is limited to a single application, irrigating at this stage ensures the development of a robust root system and initial tillers, which prevents severe, permanent yield reductions.

48. (D) Between Field Capacity and allowable depletion limit
To maximize crop performance, irrigation scheduling aims to maintain soil water within the readily available moisture range. This range is bounded by field capacity at the upper limit and the management allowable depletion threshold at the lower limit. Preventing soil moisture from falling below this threshold ensures the crop avoids transpirational stress.

49. (A) Neutron moisture meter
Tensiometers, gypsum blocks, and granular matrix sensors are designed to directly or indirectly measure soil matric potential, representing the tension holding water in soil. In contrast, a neutron moisture meter measures soil volumetric water content by detecting thermalized neutrons, rather than measuring the suction or energy state of the water.

50. (C) I only
Tensiometers operate effectively only within a narrow, wet range, typically between zero and zero point eight bars of tension. At higher suction levels, air enters the ceramic cup, breaking the internal vacuum and causing the device to fail, making assertions of a fifteen-bar operating range scientifically incorrect.

51. (A) The vacuum breaks, causing incorrect readings.
Tensiometers function by establishing a hydraulic equilibrium between the water inside the tube and the surrounding soil. When tension exceeds zero point eight bars, the soil pulls water out rapidly, and air enters through the porous ceramic cup. This breaks the internal vacuum, preventing any further accurate measurement of matric potential.

52. (B) 25-50%
Management allowable depletion is the fraction of available soil water that can be extracted without causing significant crop stress. For sensitive crops, this limit is typically set between twenty-five and fifty percent. Maintaining depletion within this conservative range protects

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tension gradient. This traditional system represents a localized form of subsurface porous-wall irrigation.

74. (B) Calcium carbonate
Chemical clogging in drip emitters is frequently caused by the precipitation of calcium carbonate from hard, alkaline waters. As water temperature rises or pressure drops within the emitters, dissolved bicarbonate ions react with calcium to form insoluble calcium carbonate scale. This white precipitate gradually restricts flow, causing emitter clogging.

75. (A) I and III
Drip irrigation minimizes evaporation and deep percolation, achieving higher application efficiency than surface flooding. By applying water only along crop rows, it restricts weed growth in dry inter-row spaces. However, sprinkler irrigation is unsuitable for heavy clay soils, as its application rate often exceeds the low clay infiltration capacity.

76. (C) Root intrusion into emitters
Subsurface drip irrigation places laterals and emitters directly within the root zone, preventing soil surface evaporation. However, plant roots naturally grow toward moisture sources, which leads to root intrusion into the emitter orifices. This physical blockage disrupts water distribution uniformity and requires chemical treatment or physical barriers to manage effectively.

77. (D) Water delivered to field divided by water diverted from source
Water conveyance efficiency quantifies the effectiveness of the canal or pipe network in transporting water. It is mathematically defined as the ratio of the volume of water delivered to the field inlet to the volume diverted from the reservoir or river source. This metric accounts for seepage and evaporation losses.

78. (C) Water conveyance efficiency
Poorly maintained, unlined earthen canals suffer from high seepage losses through the porous bottom and banks, alongside high evaporation rates. Because these losses occur during transport from the source to the field boundary, they directly reduce the water conveyance efficiency, while other field application metrics remain unaffected.

79. (B) Application efficiency
Drip irrigation delivers water directly to the crop root zone at a slow rate, minimizing surface runoff and deep percolation. Consequently, it achieves a dramatic increase in water application efficiency compared to surface flooding, where large volumes of water are lost to uncropped areas, deep drainage, and direct surface evaporation.

80. (D) III only
Storage efficiency measures how much of the soil water deficit is filled during irrigation. When the root zone is severely under-irrigated, the volume of water stored is much lower than the actual storage capacity, resulting in low storage efficiency. This renders assertions of higher efficiency under under-irrigated conditions incorrect.

81. (B) 60%
Water application efficiency is calculated by dividing the volume of irrigation water stored in the crop root zone by the total volume of water applied to the field. Dividing sixty millimeters of stored water by the one hundred millimeters applied, and multiplying by one hundred, yields an application efficiency of sixty percent.

82. (C) Precise land leveling and grading
Water distribution efficiency is maximized when water flows uniformly across the entire field area. Precise land leveling and grading eliminate high and low spots, preventing localized ponding and dry areas. This ensures a uniform depth of water infiltration across the soil profile, thereby directly improving overall distribution uniformity.

83. (A) Total water applied, rainfall, and soil water
Field Water Use Efficiency is a standard agronomic metric that measures crop productivity relative to total water inputs. It is calculated by dividing the final crop yield by the sum of irrigation water applied, seasonal rainfall received, and the profile soil water depleted between planting and harvest.

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84. (D) Excessive nitrogen fertilization maximizes WUE under severe drought.
Agronomic strategies like mulching, selecting short-duration crop varieties, and optimal plant spacing enhance water use efficiency by reducing unproductive evaporation and optimizing transpiration. However, applying excessive nitrogen under severe drought induces lush

vegetative growth, which depletes limited soil water rapidly, causing crop failure and lowering water use efficiency.

85. (B) I, II and IV
Stomatal-closing and film-forming antitranspirants successfully reduce water loss, while growth retardants enhance root growth. However, reflectant types decrease leaf temperature by increasing albedo. Furthermore, antitranspirants are expensive and restrict carbon dioxide assimilation, making them uneconomical for large-scale cereal production, which renders statements three and five incorrect.

86. (C) Coordinated use of surface and groundwater
Conjunctive use of water resources refers to the coordinated and planned management of both surface water and groundwater within an agricultural command area. By combining these sources, managers can optimize water availability, buffer against seasonal canal water shortages, improve overall system flexibility, and enhance crop water security throughout the year.

87. (D) Waterlogging and salinization
Excessive canal irrigation often leads to high seepage losses, causing the localized water table to rise toward the soil surface. This induces waterlogging and brings dissolved salts into the root zone via capillary action. Pumping groundwater for conjunctive use lowers the water table, preventing waterlogging and mitigating soil salinization.

88. (A) Fresh water at sensitive stages, saline water at tolerant stages
Crops exhibit varying sensitivity to salinity during different growth stages, with early growth and flowering being highly vulnerable. A practical conjunctive use strategy involves applying fresh canal water during these critical, sensitive stages, and utilizing saline groundwater during later, more tolerant vegetative or maturity phases to minimize salinity-induced yield loss.

89. (B) Lining canals fully to prevent any seepage to the aquifer
Integrated water management aims to coordinate rain, surface, and groundwater replenishment. Directing rainwater into recharge borewells and constructing percolation tanks actively recharge aquifers. In contrast, lining canals fully prevents seepage, which blocks natural groundwater recharge and isolates the surface water system, contradicting integrated resource replenishment principles.

90. (C) (A) is true but (R) is false.
Deficit irrigation strategies intentionally apply water below the full crop evapotranspiration requirement to optimize water productivity. However, the objective is not to eliminate yield losses entirely, but rather to minimize minor yield reductions while saving significant water volumes, which can then be used to irrigate additional land areas.

91. (A) Improved fruit quality and controlled vigor
Regulated deficit irrigation applies controlled water stress during specific non-critical vegetative growth phases of fruit trees. This practice successfully limits excessive vegetative canopy development and shoot growth. Consequently, assimilates are redirected toward fruit development, which improves fruit quality, enhances sugar concentration, and controls overall tree structural vigor.

92. (C) SAR : Evaluates sodium hazard relative to calcium and magnesium
The Sodium Adsorption Ratio is a critical water quality index that quantifies the relative concentration of sodium ions to calcium and magnesium ions in irrigation water. This ratio directly predicts the potential for sodium to displace exchangeable calcium and magnesium in the soil, which can lead to clay dispersion.

93. (D) Very high salinity water
Irrigation water with an electrical conductivity exceeding two point twenty-five decisiemens per meter is classified as very high salinity water. Water with a conductivity of four point zero decisiemens per meter falls into this category, representing a severe salinity hazard that requires salt-tolerant crops and extensive leaching.

94. (C) Soil dispersion and reduced infiltration
Continuous application of water with a high Sodium Adsorption Ratio and low Electrical Conductivity promotes the displacement of calcium and magnesium by sodium on clay exchange sites. This high exchangeable sodium percentage causes soil aggregates to disperse when wet, clogging soil pores and drastically reducing water infiltration.

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95. (B) P-4, Q-1, R-3, S-2
Specific ions cause distinct toxicities. Boron toxicity leads to yellowing and necrosis at leaf tips, common in arid zones. Chloride toxicity causes leaf marginal necrosis and burning. Sodium toxicity causes tip burn and accumulates in woody plants. Bicarbonate toxicity induces iron chlorosis by raising pH and immobilizing iron in soil.

96. (D) EC of irrigation and soil drainage water
The leaching requirement is the fraction of irrigation water that must pass through the root zone to control soil salinity. This value is mathematically determined by the ratio of the electrical conductivity of the applied irrigation water to the maximum permissible electrical conductivity of the soil drainage water.

97. (A) Equitable and rotational distribution of canal water
Warabandi is a traditional rotational water allocation system implemented in canal commands of Northern India. It schedules water distribution to fields based on a pre-determined time roster proportional to holding size. This system ensures equitable water sharing among head, middle, and tail-end farmers under conditions of scarcity.

98. (C) Irrigation potential created and utilized
The Command Area Development program was launched in India to optimize water use efficiency in major and medium canal irrigation systems. It specifically aims to bridge the significant gap between the irrigation potential created through dam and canal construction and the actual potential utilized by farmers in fields.

99. (A) Main canal → Branch canal → Distributary → Minor → Watercourse
A large-scale canal network is organized in a hierarchical branching structure. Water flows from the headworks into the main canal, then divides into branch canals. From there, it enters distributaries and minor canals, and finally flows into the watercourses that deliver the water directly to agricultural fields.

100. (C) (A) is true but (R) is false.
Participatory Irrigation Management involves transferring system maintenance and water distribution responsibilities to local farmers. While this improves local water governance, it does not mean the government completely stops funding major dam constructions. Large-scale infrastructure remains under state financial and technical oversight, making the second statement false.

101. (B) Better field channel maintenance and fee collection
Water User Associations are community-based organizations that empower farmers to manage tertiary-level irrigation channels. Their establishment fosters collective action, leading to regular physical maintenance of field channels, equitable water distribution among members, and more reliable collection of water fees to fund local operational costs.

102. (C) Adjoining landowners have rights to reasonable water use.
The riparian rights doctrine is a legal framework governing water allocation. It establishes that landowners whose properties border a natural watercourse, such as a river or stream, possess the legal right to make reasonable use of that water, provided their extraction does not harm downstream users.

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103. (D) The State List
Under the Constitution of India, water is primarily a state subject. Entry seventeen of the State List vests the authority over water supplies, irrigation canals, drainage embankments, water storage, and water power with the respective state governments, allowing them to legislate and manage water resources locally.

104. (A) National Water Policy
The National Water Policy of India provides the comprehensive framework for the planning, development, and efficient management of water resources. It outlines guiding principles for equitable water allocation across different sectors, emphasizes conservation strategies, and addresses water pricing mechanisms to ensure sustainable water use nationwide.

105. (B) P-3, Q-4, R-1, S-2
Nitrogen forms differ in soil mobility. Nitrate is highly mobile and prone to leaching. Ammonium is held on cation exchange sites, showing restricted mobility. Urea is highly mobile before undergoing hydrolysis to ammonium. Organic nitrogen must mineralize slowly, remaining

125. (D) Subsurface drip irrigation
Subsurface drip irrigation delivers water directly to the plant root zone through buried lateral pipes and emitters. This localized application virtually eliminates surface runoff, deep percolation losses, and direct soil surface evaporation. As a result, it achieves the highest theoretical water application efficiency among all modern and conventional agricultural irrigation methods.

126. (C) Improve grape quality by restricting vegetative canopy growth
Regulated deficit irrigation involves deliberately applying less than the full water requirement during specific growth stages. In vineyards, imposing a controlled water deficit during the early berry development stage restricts excessive vegetative canopy growth. This shifts plant energy from leaves to berries, enhancing fruit quality, sugar concentration, and valuable flavor compounds.

127. (B) Simpler, but highly vulnerable to localized micro-environmental errors
The pan evaporation method offers a straightforward and cost-effective approach to estimating reference crop evapotranspiration without complex electronic sensors. However, the water temperature and evaporation rates inside the open metal pan are highly sensitive to localized micro-environmental factors such as surrounding vegetation, wind obstruction, and paint color, which can introduce significant errors.

128. (D) Drinking water
The National Water Policy of India establishes a clear, structured hierarchy for the allocation and planning of countrywide water resources. It explicitly assigns the absolute highest priority to drinking water needs for human beings and livestock, followed subsequently by irrigation, hydro-power generation, industrial activities, and other secondary ecological and commercial requirements.

129. (A) Evapotranspiration minus effective rain and soil moisture contribution
Net irrigation requirement is the depth of water needed to meet crop consumptive demands. It is calculated by subtracting the amount of effective rainfall and any capillary upward flow of groundwater or antecedent soil moisture contribution from the total potential crop evapotranspiration, determining the precise depth of irrigation water that must be applied.

130. (C) Field capacity
When a soil is thoroughly saturated and allowed to drain freely under the influence of gravity, the rapid downward movement of excess water eventually ceases after two to three days. The remaining water content held in the micro-pores by surface tension and capillary forces represents the field capacity of that soil.

131. (A) Overall irrigation efficiency
The gross irrigation requirement represents the total volume of water that must be diverted from the source to satisfy crop needs. It is calculated by dividing the net irrigation requirement by the overall irrigation efficiency of the system. This accounts for unavoidable water losses during conveyance, field distribution, and root zone storage.

132. (D) Phase change of liquid water to vapor consumes significant latent heat.
Transpiration induces leaf cooling because of thermodynamics. When liquid water inside the leaf transitions into gaseous water vapor, it must absorb a massive quantity of energy, known as the latent heat of vaporization. This heat energy is extracted directly from the leaf tissues, resulting in a measurable drop in leaf canopy temperature.

133. (B) Vacuum tensiometer tube
A standard US Class A Evaporation Pan is configured with specific components to measure open-water evaporation rates accurately. These include a high-precision hook gauge inside a metal stilling well to measure water level changes, and a wooden support pallet. A vacuum tensiometer is a completely separate soil science tool used to measure soil matric potential.

134. (B) 1 to 2 $k\frac{g}{c}m^2$
Drip irrigation is classified as a low-pressure localized irrigation system. To ensure optimal emitter performance and maintain uniform water discharge without bursting or damaging plastic lateral pipes, drip networks typically operate within a pressure range of one to two kilograms per square centimeter, which is easily maintained by pressure regulators.

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115. (A) P-2, Q-4, R-1, S-3
Different scientific instruments are utilized to monitor plant water status. Leaf water potential is measured using the Scholander pressure chamber, while stomatal conductance is measured with a leaf porometer. Canopy temperature, reflecting crop water stress, is assessed remotely using an infrared thermometer, and sap flow through plant stems is quantified using heat pulse velocity sensors.

116. (D) Visual and tactile assessment of soil sample moisture
The feel and appearance method is a rapid, practical, field-based technique where farmers obtain a soil sample from the active root zone and judge its moisture level. By squeezing the soil to form a ball or ribbon, and evaluating its texture, cohesion, and moisture film, they can estimate the depletion of available water.

117. (B) Absolutely no evaporation losses during application
Micro-sprinklers distribute water through the air in fine droplets, which inevitably results in some evaporation losses before the water reaches the soil surface. Drip irrigation, conversely, applies water directly onto or beneath the soil surface, minimizing airborne evaporation. Therefore, avoiding all evaporation losses is not an advantage of micro-sprinklers over drip systems.

118. (C) Timely and equitable water delivery to all command area farmers
Warabandi is a traditional, structured rotational water distribution system employed in canal commands. It allocates a specific day and precise time slot to each farmer based on their holding size. This operational design ensures that both head-reach and tail-reach farmers receive their fair and equitable share of water in a highly predictable manner.

119. (D) The land area that can be physically and economically irrigated by a project
In irrigation engineering, the command area represents the total geographic zone that can be successfully irrigated by a specific canal, reservoir, or well system. This area is determined by the local topography, available water volume, and the economic feasibility of laying out canals, making it the primary administrative unit for agricultural water planning.

120. (A) Carbonate, Bicarbonate, Calcium, and Magnesium
Residual Sodium Carbonate is a critical water quality parameter used to assess the sodium hazard of irrigation water. It is calculated by subtracting the milliequivalent concentrations of calcium and magnesium from the sum of carbonate and bicarbonate concentrations. High values indicate a risk of calcium precipitation, which degrades soil physical structure.

121. (B) The fraction of applied irrigation water that drains below the root zone
The leaching fraction represents the proportion of applied irrigation water that is intentionally allowed to drain through and below the active crop root zone. This deep drainage carries dissolved salts out of the root zone, preventing soil salinization and maintaining a favorable salt balance necessary for long-term agricultural sustainability in irrigated regions.

122. (B) Soil osmotic potential will drop, severely restricting plant water uptake.
Continuous irrigation with saline water causes dissolved salts to accumulate in the root zone. This accumulation increases the concentration of solutes in the soil solution, which drastically lowers the soil water osmotic potential. Consequently, the gradient between the root and soil is reduced, making it highly difficult for plants to extract necessary water.

123. (A) Ammonium
When urea is applied through a fertigation system, it enters the soil in an organic form. The ubiquitous soil enzyme urease rapidly catalyzes the hydrolysis of urea, converting it into ammonium carbonate, which then dissociates into ammonium ions. Plants can directly absorb this ammonium, or soil bacteria can further nitrify it into nitrate.

124. (C) Distribution Uniformity :
$$\frac{\text{Average depth of lowest quarter in filtrated}}{\text{Average depth in filtrated}} \times 100$$
Distribution uniformity is a key indicator of how evenly water is applied across an irrigated field. It is mathematically calculated by dividing the average depth of water infiltrated in the lowest one-quarter of the field by the average depth infiltrated across the entire field, multiplied by one hundred to express the value as a percentage.

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essentially immobile in the soil profile under irrigation conditions.

106. (B) Severe nitrate leaching below root zone
Sandy soils have large macropores and low water retention capacity. When nitrogen fertilizer is applied just before a heavy basin irrigation event, the large volume of water rapidly percolates downward. This process carries highly mobile nitrate ions deep into the soil profile below the active root zone, causing significant nutrient loss and potential groundwater contamination.

107. (A) Chemical precipitation and emitter clogging
Soluble phosphorus fertilizers easily react with calcium, magnesium, or iron ions present in irrigation water to form highly insoluble phosphate compounds. These solid chemical precipitates rapidly accumulate within the narrow pathways of drip system emitters, causing severe physical clogging, reduced water application uniformity, and localized crop water stress across the entire field.

108. (C) The application of agricultural chemicals through irrigation systems
Chemigation represents an advanced agricultural technique where chemicals such as fertilizers, systemic insecticides, herbicides, fungicides, and soil conditioners are distributed directly to crops through irrigation water. This integrated system enhances application uniformity, saves substantial labor, minimizes mechanical soil compaction, reduces chemical exposure to farm operators, and allows highly timely agronomic treatments for better yields.

109. (D) Maintenance of a constant fertilizer concentration in the water flow
Unlike fertilizer bypass tanks which experience a progressive decay in chemical concentration during irrigation runs, venturi injectors pull liquid stock solution at a steady rate. This hydraulic suction maintains a uniform concentration of fertilizer throughout the entire application window, ensuring that plants receive equal nutrient levels from the beginning to the end of watering.

110. (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
Urea is exceptionally well-suited and widely utilized for fertigation because of its outstanding chemical properties. It is highly soluble in water, does not hydrolyze rapidly in pipelines, and does not react with common irrigation water constituents to form solid precipitates, which completely avoids clogging emitters while providing an efficient, readily available nitrogen source.

111. (B) Capillary rise equation of pore suction
The upward movement of water from a shallow water table into the root zone against gravity is driven by capillary forces within the narrow pores of the soil matrix. This physical phenomenon is described mathematically by the capillary rise equation, which relates the height of rise to soil surface tension, contact angle, and pore radius.

112. (D) Hargreaves-Samani equation
When complete meteorological data is unavailable, the Hargreaves-Samani equation provides a reliable empirical approach to estimate reference crop evapotranspiration. It requires only maximum and minimum air temperatures along with extraterrestrial radiation, which is determined directly from the geographical coordinates and the specific day of the year, making it highly useful for data-sparse agricultural regions.

113. (A) The K_c for a crop is typically highest during the mid-season stage when the canopy is fully developed.
Crop coefficient values vary dynamically across growth stages to reflect physiological and anatomical changes. During the mid-season stage, the leaf area index reaches its maximum value and the canopy completely shades the ground. This results in peak transpiration rates and minimal surface soil evaporation, driving the overall crop coefficient to its highest value during the crop cycle.

114. (C) Prevention of permanent wilting and catastrophic crop failure
In rainfed or dryland farming systems, dry spells often coincide with critical crop growth stages, threatening total crop loss. Life-saving irrigation refers to the minimal application of water during these extreme drought periods. Its fundamental objective is to prevent the soil moisture from falling below the permanent wilting point, thereby ensuring survival until the next rainfall.

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135. (C) Minimize leaching of nutrients below the root zone while allowing subsequent flushing
Injecting fertilizers during the middle phase of the irrigation run ensures that the soil is already moistened, slowing down deep water movement. Following injection with a clean water phase flushes any residual nutrients from the pipelines and emitters, preventing biological clogging, while keeping the fertilizer confined to the active root zone.

136. (A) Unsaturated flow is driven purely by gravitational potential.
Water movement under unsaturated conditions is governed primarily by matric potential gradients, which represent the strong cohesive and adhesive forces attracting water to soil particles. Gravity plays only a minimal, secondary role compared to suction forces. This allows capillary movement to occur in any direction, including horizontally and vertically upward.

137. (B) Gross Command Area (GCA)
Gross Command Area represents the entire geographic boundary enclosed within an irrigation project. It encompasses the total physical tract of land, which includes both the culturable land suitable for agriculture and non-culturable areas such as forest reserves, village settlements, wasteland, roads, and rocky terrain that cannot be physically or economically irrigated.

138. (B) Water is extracted faster than the aquifer's lateral flow can replenish it
When a well is pumped, groundwater is physically drawn from the surrounding aquifer. If the rate of extraction exceeds the lateral hydraulic conductivity and flow rate of water through the porous aquifer medium, the water table declines locally. This localized drawdown forms a characteristic three-dimensional cone of depression around the well.

139. (A) The maximum quantity of water that can be continuously withdrawn without causing adverse impacts like severe depletion
Safe yield is a fundamental concept in sustainable groundwater management. It defines the maximum volumetric rate at which groundwater can be continuously pumped from an aquifer without triggering undesirable consequences, such as progressive water table decline, drying up of shallow wells, land subsidence, or seawater intrusion in coastal aquifer basins.

140. (C) Water User Association (WUA) : Operation of micro-level canal distribution networks
Water User Associations are cooperative organizations formed by local farmers to manage irrigation systems at the micro-level. These groups assume full operational responsibility for distributing canal water equitably among members, collecting local irrigation fees, and carrying out the physical maintenance of tertiary watercourses and field channels to improve overall water security.

141. (D) Rapid water table rise, eventually leading to waterlogging
Introducing canal irrigation to arid areas adds a massive volume of water to the hydrological system. In the absence of adequate natural or artificial drainage, deep percolation from unlined canals and over-irrigated fields continuously recharges the groundwater. This process drives a steady rise in the local water table, culminating in waterlogging.

142. (C) Selecting highly salt-tolerant crop variety for planting
Managing saline irrigation water requires appropriate agronomic strategies. Selecting and cultivating crop varieties with high physiological salt tolerance represents a highly effective on-farm biological management practice. These specialized varieties can maintain cell turgor and active metabolic functions despite elevated root zone salinity, securing acceptable yields where other sensitive crops completely fail.

143. (C) 210 mm
The depth of available water in the root zone is calculated using the difference between field capacity and permanent wilting point, multiplied by the bulk density and root zone depth. Here, the calculation yields fifteen percent multiplied by one point four and one thousand millimeters, which equals exactly two hundred and ten millimeters of available water.

144. (D) Can tap deeper soil moisture, requiring less frequent irrigation cycles
Deep-rooted agricultural crops such as safflower and cotton possess extensive root networks that penetrate deep into the lower soil profile. This physiological feature enables them to extract stored moisture from deep subsoil layers, allowing them to withstand longer intervals between waterings and requiring significantly

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less frequent irrigation events than shallow-rooted crops.

145. (A) The change in hydraulic head per unit distance of flow
The hydraulic gradient is a fundamental dimensionless quantity in groundwater hydrology. It represents the physical driving force behind groundwater movement and is defined as the change in total hydraulic head per unit distance along the flow path in a porous medium, pointing in the direction of the steepest decrease in head.

146. (C) Soil texture and land slope
In border irrigation, the maximum non-erosive stream size is the largest water flow rate that can be introduced without causing soil erosion. This critical limit depends on soil texture, which dictates cohesiveness and intake rate, and land slope, which controls the gravitational acceleration and velocity of the overland water surface flow.

147. (A) Flow velocity will be low, leading to potential silt deposition
Designing an irrigation channel with an extremely flat longitudinal slope reduces the hydraulic gradient driving water movement. According to open-channel flow equations, this lower gradient results in very low water velocities. When the velocity drops below the critical silting velocity, suspended sediment particles settle, leading to severe channel siltation and clogging.

148. (C) 62.5 mm
The irrigation water to cumulative pan evaporation ratio is used to schedule waterings. To find the cumulative pan evaporation value at which to irrigate, the applied water depth is divided by the ratio. Dividing fifty millimeters by the ratio of zero point eight yields exactly sixty-two point five millimeters of cumulative pan evaporation.

149. (B) Sorghum : Maturity and harvest stage
Crops have specific critical growth stages during which moisture deficit causes the most severe damage to yield. For sorghum, the flowering and grain-stuffing stages are highly sensitive, whereas the final maturity and harvest stage is relatively insensitive to water deficits, making the association of maturity as the critical stage incorrect.

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150. (C) Poor fertilization resulting in completely barren cobs
The silking stage in maize represents a highly critical reproductive window. Severe water stress at this stage delays silking relative to pollen shed, creating a physical gap in timing between the two processes. This results in poor fertilization, incomplete seed set, and ultimately barren or partially filled cobs, decimating grain yield.

151. (D) Soil hydraulic and capillary properties
Emitter spacing in drip systems must match the lateral and vertical water movement pattern within the soil. Coarse sandy soils with high hydraulic conductivity exhibit narrow, vertical wetted patterns, requiring closer spacing. In contrast, fine-textured clay soils promote extensive lateral capillary movement, allowing wider emitter spacing for uniform root zone wetting.

152. (A) Moisture sensors paired with weather-based ET models
For large-scale orchard management, combining real-time soil moisture sensors with climate-driven evapotranspiration models represents the most efficient and robust scheduling strategy. While weather models estimate general water use across the farm, localized sensors provide precise, site-specific soil water depletion data, allowing managers to apply irrigation water only when and where required.

153. (B) Field Capacity and Permanent Wilting Point
Available Water Capacity represents the volume of water stored in the soil that plants can successfully extract for growth. The upper limit of this water reservoir is defined by the field capacity, whereas the lower boundary is defined by the permanent wilting point, below which plants cannot overcome suction forces.

154. (C) Non-return check valve and vacuum breaker assembly
When introducing chemical solutions into an irrigation system, there is a risk that temporary system shutdown or pressure drop will cause backward siphonage. To prevent toxic agrochemicals from flowing backward and contaminating drinking water aquifers or municipal sources, installing a non-return check valve paired with a vacuum breaker is legally mandated.

155. (A) Electrical resistance variations
Granular matrix sensors contain two electrodes embedded within a porous gypsum-like matrix that equilibrizes with surrounding soil moisture. As soil dries, water is drawn out of the matrix, increasing electrical resistance between the electrodes. Conversely, higher soil moisture increases water content in the matrix, lowering electrical resistance signals for easier monitoring.

156. (C) It lowers water tables artificially to provide an aerated root zone
In areas with shallow groundwater tables, agricultural crops suffer from poor soil aeration and root hypoxia. Subsurface drainage systems use buried corrugated perforated tubes to collect and carry away excess gravitational water. This process artificially lowers the water table, establishing a well-aerated soil zone crucial for healthy root respiration and development.

157. (D) Adopt water-saving technologies and improve irrigation efficiency
Charging for water based on the actual volume consumed, rather than flat-rate area pricing, provides a strong financial incentive for conservation. Under volumetric pricing, reducing water use directly lowers production costs, motivating farmers to transition from flood irrigation to efficient technologies like drip systems, thereby improving overall farm water use efficiency.

158. (C) Provide soil moisture for uniform seed germination and seedling growth
Pre-sowing irrigation is applied several days before sowing when the surface soil has dried out. This critical water application replenishes the seedbed moisture reservoir, establishing the optimal soil water status needed to trigger rapid seed imbibition, ensure highly uniform germination, and support the initial vegetative growth of emerging crop seedlings.

159. (B) Building massive new multipurpose dams
The Command Area Development program was launched to bridge the gap between irrigation potential created and actually utilized. It focuses on farm-level infrastructure development, such as laying out field channels, constructing micro-drainage networks, land leveling, and implementing the warabandi distribution system. Creating massive new multipurpose dams is a separate, major water resource engineering activity.

160. (D) Row crops like cotton, maize, and potato
Furrow irrigation is highly advantageous for cultivating row crops because water is introduced into small channels between crop ridges. This design keeps the plant crown and stems dry on top of the ridges while wetting the roots through capillary action, preventing root rot and soil crusting around emerging crop vegetative seedlings.

161. (A) Sprinkler or drip irrigation
Undulating topography presents a major challenge for surface irrigation due to high runoff and poor uniformity unless extensive land leveling is performed. Sprinkler and drip irrigation systems apply water through closed pressurized pipe networks, remaining completely independent of surface topography. They distribute water uniformly across slopes without requiring expensive land-shaping activities.

162. (C) Energy reduction from dissolved solute particles
Osmotic potential is a component of the total soil water potential. It is caused by the presence of dissolved solutes in soil water. These solutes restrict the kinetic activity and freedom of water molecules, effectively lowering their free energy status compared to pure water, which creates a suction force that limits plant water absorption.

163. (A) Evapotranspiration
In agricultural hydrology, consumptive use represents the total quantity of water required by a crop for vegetative growth. It consists of the water transpired through the plant stomata plus the water evaporated from the surrounding soil surface. Because this combined water volume is lost to the atmosphere, consumptive use is synonymous with evapotranspiration.

164. (D) Monthly mean temperature and daytime hours
The Blaney-Criddle empirical equation is a simple, temperature-based model developed to estimate seasonal crop consumptive water use. This calculation relies on two primary independent variables: the monthly mean air temperature and the monthly percentage of annual daytime hours, which is determined

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directly from the latitude of the agricultural crop field.

165. (B) Catch can tests of uniformity
Sprinkler distribution uniformity is measured in the field using a grid of identical catch cans laid out across the sprinkler pattern. During the test, the cans collect water discharged by the operating sprinklers. By measuring the volume of water collected in each container, engineers can calculate the Christiansen coefficient of uniformity.

166. (C) FAO-56 Penman-Monteith
The FAO-56 Penman-Monteith equation is the globally accepted standard for calculating reference crop evapotranspiration. Unlike simpler empirical equations, it is a physics-based model that integrates energy balance and aerodynamic mass transfer principles, incorporating multiple weather parameters including net radiation, air temperature, wind speed, and relative humidity for highest overall accuracy.

167. (D) Interference with cellular enzymes and metabolism
Excess accumulation of specific ions like sodium or chloride in plant leaves induces specific toxicity symptoms. Once inside leaf tissues, elevated concentrations of these ions alter cell membrane integrity, disrupt essential potassium uptake, and directly interfere with key cellular enzymes and metabolic processes, leading to marginal leaf burn and reduced photosynthesis.

168. (A) Cut-throat flume : Measures open channel water discharge
A cut-throat flume is a critical, widely used device in irrigation networks designed to measure open-channel flow rates. It features a flat bottom and lacks a throat section, which minimizes flow energy losses. Measuring the upstream water depth within the flume allows the precise mathematical calculation of volumetric water discharge.

169. (B) The travel time from the furthest point in the catchment to the outlet
In hydrology, the time of concentration represents a key watershed parameter. It is defined as the time required for runoff water to travel from the hydrologically most distant point in the catchment basin to the designated outlet point, determining the peak discharge timing and shaping the overall catchment runoff hydrograph.

170. (B) Subsurface geological mineral color
Crop water requirements are governed by climate, which dictates atmospheric demand, crop characteristics like leaf area index and development stage, and soil properties like texture and depth which influence water retention. The visual color of deep subsurface geological minerals plays absolutely no biological or physical role in crop water use.

171. (A) The irrigable land area per unit of continuous water flow over a crop season
In irrigation planning, the duty of water is a fundamental index of water-use efficiency. It is defined as the total land area that can be successfully irrigated by a continuous, constant discharge of water over the entire base period of the crop, typically expressed in hectares per cubic meter per second.

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172. (C) Time between the first pre-sowing irrigation and final watering
In agricultural engineering, the base period of a crop is the precise duration of time over which irrigation water is active. It is defined as the elapsed time in days between the first application of water at the pre-sowing stage and the very last irrigation event delivered just prior to crop harvest.

173. (D) Requirement of continuous standing water for weed control and growth
Rice cultivation relies heavily on maintaining a continuous water depth of five to ten centimeters in the field. This water layer suppresses weed growth, buffers micro-climate temperature, and satisfies physiological crop demands. The constant ponding causes high percolation and seepage losses, driving the total water requirement of rice much higher than wheat.

174. (C) $\Delta = \dfrac{8.64 \times B}{D}$
The mathematical relationship among the duty of water, the base period, and delta is derived by balancing water volumes. Equating the total volume applied to the land area yields the standard formula where delta equals eight point six four times the base period in days divided by the duty in hectares per cumec.

175. (C) + 5 mm
Based on the field water balance equation, change in soil moisture storage is equal to total water inputs minus total water outputs. Inputs include precipitation and irrigation, totaling one hundred and fifty millimeters. Outputs include evapotranspiration, runoff, and deep percolation, totaling one hundred and forty-five millimeters, yielding a positive five millimeter storage change.

176. (D) It enhances the activity of aerobic soil microorganisms.
Waterlogging fills soil pore spaces completely with water, blocking the diffusion of oxygen from the atmosphere. This rapid depletion of oxygen establishes strict anaerobic conditions in the root zone. Under these hypoxic conditions, the population and metabolic activities of beneficial aerobic soil microorganisms drastically decrease, while anaerobic microbes rapidly proliferate.

177. (A) Low soluble salts and an exchangeable sodium percentage (ESP) above 15%
Sodic soils are characterized by an excess of exchangeable sodium ions on the soil clay complex relative to total soluble salts. They possess an exchangeable sodium percentage greater than fifteen, low electrical conductivity, and a soil pH above eight point five, causing severe clay dispersion, aggregate structural collapse, and poor physical water infiltration.

178. (C) Sodic soils require gypsum application followed by leaching, while saline soils require only leaching
Saline soils contain high concentrations of soluble salts that can be washed downward out of the root zone using freshwater leaching alone. In contrast, sodic soils contain bound exchangeable sodium. Reclaiming them requires applying gypsum to replace sodium with calcium on the soil complex, followed by leaching to wash away the displaced sodium.

179. (A) Institutionalize farmer participation in the operation and maintenance of irrigation systems
Participatory Irrigation Management is an institutional framework designed to actively involve water users in the management of public irrigation schemes. By organizing farmers into local Water User Associations, the policy transfers operational authority and maintenance responsibilities of tertiary canal networks to the community, improving equity, conflict resolution, and water use efficiency.

180. (B) 1987
India adopted its first National Water Policy in September nineteen eighty-seven, established under the leadership of the Ministry of Water Resources. This landmark policy document was formulated to provide a structured national framework, establishing clear priorities for allocating water, managing resources, and addressing emerging hydrological issues across different social sectors.

181. (B) Groundwater rights are tied to land ownership, which often leads to unregulated extraction.
Under traditional British common law doctrines historical in India, groundwater rights remain legally tied to surface land ownership. A landowner owns all underlying groundwater, permitting them to pump unlimited quantities. This legal framework makes regulating extraction highly difficult, leading to widespread groundwater over-exploitation and rapid aquifer depletion across many states.

182. (C) National monitoring and assessment of groundwater resources
The Central Ground Water Board is the apex national organization in India dedicated to managing groundwater. Its primary mandate is to monitor regional water level trends, carry out exploratory drilling, compile hydrogeological maps, and publish regular assessments of groundwater extraction versus recharge rates to guide sustainable water extraction policy.

183. (D) Encourage water conservation by linking charges to the actual volume of water consumed
Volumetric pricing establishes a direct relationship between water usage and cost. By billing agricultural users based on the actual volume consumed rather than irrigated land area, it creates a financial disincentive for over-watering. This economic signal encourages farmers to optimize their application schedules and adopt high-efficiency drip irrigation methods.

184. (A) Combining conjunctive use, crop diversification, and micro-irrigation
Addressing severe aquifer overdraft requires an integrated water management strategy. Combining the conjunctive use of surface and

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(C) A is true but R is false.
(D) A is false but R is true.

2025
9. What is the fundamental diagnostic criterion used to differentiate saline-sodic soils from purely sodic soils?
(A) A Sodium Adsorption Ratio (SAR) of less than 13
(B) A soil pH value consistently higher than 9.0
(C) A complete absence of neutral soluble salts in root zones
(D) An electrical conductivity greater than 4 dS/m

2003
10. The dominant process responsible for the genesis of sodic soils in semi-arid regions is the:
(A) Carbonate precipitation of calcium and magnesium, raising relative sodium
(B) Accumulation of sesquioxides and intense leaching of exchangeable basic cations
(C) Capillary rise of highly acidic groundwater during prolonged dry climate spells
(D) Continuous application of high-quality, low-salinity surface irrigation water

2021
11. Which primary visual symptom on plants indicates specific chloride toxicity typically found in salt-affected soils?
(A) Interveival chlorosis of younger leaves
(B) Marginal necrosis and leaf tip burn on older leaves
(C) Stunted root growth with thickened root tips
(D) Purple coloration of the stem and lower leaf surfaces

2005
12. Match the specific ion toxicities (List I) with their corresponding physiological effects on plants (List II).
List I: Specific ion toxicities
P. Sodium toxicity
Q. Chloride toxicity
R. Boron toxicity
S. Aluminum toxicity
List II: Physiological effects on plants
1. Inhibits root cell elongation and DNA synthesis
2. Disrupts cell membrane integrity and potassium uptake
3. Causes necrosis on margins of older leaves
4. Results in chlorosis and marginal necrosis specifically at leaf tips
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-1, Q-4, R-2, S-3
(D) P-2, Q-1, R-4, S-3

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2006
13. During seed germination, excessive soil salinity primarily restricts radicle emergence by:
(A) Lowering soil osmotic potential, preventing water imbibition
(B) Inducing direct chemical burns on the seed coat and embryo tissues
(C) Stimulating premature enzymatic degradation of nutrient-storing cotyledons
(D) Creating a hard surface crust that strictly limits oxygen diffusion

2018
14. Which specific ion accumulation in the plant tissue is strongly associated with the degradation of chlorophyll and reduction of photosynthetic efficiency in salt-affected environments?
(A) Calcium
(B) Potassium
(C) Sodium
(D) Manganese

2011
15. Consider the following statements regarding amendments used in the reclamation of sodic soils:
I. Gypsum directly supplies soluble calcium to replace exchangeable sodium.
II. Iron pyrites require microbial oxidation to produce sulfuric acid for reclamation.
III. Application of elemental sulfur immediately replaces sodium on the exchange complex.
IV. Organic manures can assist in lowering soil pH by producing organic acids during decomposition.
Which of the above statements is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II and III
(D) I and II

2024
16. The chemical equivalent weight of agricultural grade gypsum ($CaSO_4 \cdot 2H_2O$) used for calculating gypsum requirement is approximately:
(A) 50 g/eq
(B) 86 g/eq
(C) 100 g/eq
(D) 136 g/eq

fails to achieve target efficiencies. The primary bottleneck is the poor physical maintenance of tertiary canals and field channels, which suffer from siltation, weed growth, and breaches, causing severe conveyance losses and water shortages.

195. (A) Higher due to synchronization with crop demand
In drip fertigation, water-soluble nutrients are delivered directly to the active root zone in small, frequent doses that match the crop growth stage. This precise spatial and temporal synchronization minimizes nutrient losses through leaching, volatilization, or soil fixation, resulting in significantly higher nutrient use efficiency compared to conventional broadcasting methods.

196. (D) The ability to mix multiple fertilizers without forming insoluble precipitates
Fertilizer compatibility in fertigation defines whether multiple chemical fertilizers can be dissolved together in a single concentrated stock tank. Compatible fertilizers remain completely dissolved without reacting chemically, whereas incompatible fertilizers react to form insoluble solid precipitates, which can rapidly clog irrigation pipelines, filters, and narrow drip irrigation system emitters.

197. (B) Insoluble calcium sulfate precipitation and clogging
Mixing calcium nitrate and ammonium sulfate in a concentrated fertigation tank is chemically problematic. The calcium ions react directly with the sulfate ions in the solution to form calcium sulfate, which is highly insoluble gypsum. This solid compound precipitates rapidly, forming coarse crystals that clog the system filters, pipelines, and emitters.

198. (C) Sulfuric or Phosphoric acid
Phosphorus fertilizers are highly susceptible to chemical precipitation in alkaline water. To keep phosphorus ions in a soluble, plant-available orthophosphate form, an acidic environment must be maintained. Injecting strong sulfuric or phosphoric acid into the fertigation flow lowers pH, preventing calcium phosphate precipitation and keeping emitters free of mineral deposits.

199. (D) Highly soluble and suitable for fertigation
Potassium fertilizers, such as potassium chloride and potassium nitrate, are outstandingly suited for fertigation programs. They dissolve rapidly and completely in water without reacting to form solid precipitates, even in hard water. This high solubility ensures clean, uniform delivery through micro-irrigation systems without clogging any narrow drip irrigation system emitters.

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200. (A) Bernoulli's principle of pressure drop
A venturi injector operates based on Bernoulli's principle of fluid dynamics. It features a specialized constricting throat in the water pipeline. As water flows through the constriction, its velocity increases, causing a localized drop in static pressure. This low pressure creates a powerful vacuum that draws fertilizer solution into the stream.

201. (B) Sand media filter : Primarily designed to dissolve solid fertilizers
In micro-irrigation systems, a sand media filter is designed to remove physical contaminants like algae, organic matter, and fine sediments from water to prevent emitter clogging. It plays absolutely no role in dissolving solid fertilizers. Stock fertilizer solution must be completely dissolved in a separate tank before entering the irrigation lines.

202. (B) Nutrient leaching past active root zones
Pulsing, or split application in fertigation, divides the seasonal nutrient requirement into multiple small doses applied over frequent, short intervals. By coordinating nutrient application directly with immediate crop demand and avoiding large single applications, this practice prevents dissolved fertilizers from leaching deep into the soil profile below the active root zone.

203. (A) Completely insoluble granular fertilizers
Successful micro-irrigation fertigation requires fertilizers that dissolve completely and rapidly in water, leaving no suspended particles or solid residue. Granular fertilizers that are completely insoluble are entirely unsuitable, as they cannot be distributed through pipelines and would immediately block filters and cause catastrophic clogging of narrow emitter water flow paths.

204. (C) Prevent biological clogging in drip lines
Drip irrigation systems are highly susceptible to biological clogging from bacterial slime,

(D) Interlayer spaces of clay minerals

2025

28. Which type of soil acidity constitutes the largest fraction of total acidity and must be neutralized to permanently raise soil pH?
(A) Active soil solution acidity
(B) Reserve or residual acidity
(C) Exchangeable surface acidity
(D) Soluble organic acid acidity

2010

29. The most significant factor contributing to the natural genesis of acid soils in humid tropical regions is:
(A) Intense leaching of basic cations by high rainfall
(B) Gradual accumulation of alkaline-forming basic cations in the topsoil
(C) Accelerated physical weathering of limestone parent material
(D) High evaporation rates concentrating soluble sulfates on the surface

2019

30. Analyze the assertion and reason statements below and select the correct option:
Assertion (A): At pH levels below 5.5, aluminum toxicity becomes a major limiting factor for plant growth.
Reason (R): High soil acidity dissolves aluminum-bearing minerals, releasing phytotoxic Al^{3+} ions into the soil solution.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

31. Exchangeable acidity in soils is predominantly composed of which two specific ions held on the soil colloidal surfaces?
(A) Calcium and Magnesium
(B) Sodium and Potassium
(C) Iron and Manganese
(D) Hydrogen and Aluminum

2022

32. In highly acidic soils, phosphorus availability is severely restricted primarily due to fixation by:
(A) Calcium and magnesium carbonates
(B) Silicate clay minerals
(C) Iron and aluminum oxides
(D) Humic and fulvic acids

2015

33. Which essential micronutrient typically exhibits reduced availability and induces deficiency symptoms in leguminous crops grown in acid soils?
(A) Iron
(B) Molybdenum
(C) Manganese
(D) Zinc

2016

34. The primary physiological impact of aluminum toxicity on root systems in acid soils is:
(A) Excessive stimulation of lateral root branching
(B) Enhanced symbiotic nodulation
(C) Destruction of root epidermal hairs without affecting the meristem
(D) Inhibition of cell division at the root apex, causing stubby roots

2015

35. Arrange the following liming materials in descending order of their neutralizing value (Calcium Carbonate Equivalent):
I. Burnt lime (CaO)
II. Slaked lime ($Ca(OH)_2$)
III. Pure calcium carbonate ($CaCO_3$)
IV. Dolomitic limestone
(A) I, II, IV, III
(B) I, II, III, IV
(C) II, I, IV, III
(D) IV, I, II, III

2012

36. The Calcium Carbonate Equivalent (CCE) of pure burnt lime (CaO) is approximately:
(A) 100%
(B) 136%
(C) 179%
(D) 212%

2022

37. Which standard laboratory method is commonly utilized to determine the lime requirement of acid soils?
(A) SMP buffer method
(B) Walkley-Black method
(C) Bray-1 extraction method
(D) Ammonium acetate saturation method

2022

38. The principal chemical process by which lime ($CaCO_3$) neutralizes soil acidity involves the formation of which ultimate end products in the soil solution?

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CHAPTER 13

Management of Problematic Soils and Water

2007

1. Which of the following defines a problematic soil primarily characterized by physical constraints?
(A) Soils exhibiting excessive accumulation of soluble salts
(B) Soils with severe surface crusting and subsurface hardpans
(C) Soils presenting high exchangeable aluminum and low pH
(D) Soils dominated by prolonged waterlogging and reducing conditions

2008

2. In the context of problematic soils, which chemical constraint directly induces calcium deficiency and aluminum toxicity?
(A) High sodium adsorption ratio
(B) Accumulation of chlorides and sulfates
(C) Excessive calcium carbonate content
(D) Extreme soil acidity

2003

3. Consider the following statements regarding the biological constraints of problematic soils:
I. High salinity diminishes soil microbial biomass and enzyme activity.
II. Soil acidity accelerates the decomposition rate of soil organic matter.
III. Waterlogging shifts microbial respiration from aerobic to anaerobic pathways.
Which of the above statements is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2025

4. What is the approximate total area of salt-affected soils in India?
(A) 2.5 million hectares
(B) 6.7 million hectares
(C) 12.4 million hectares
(D) 18.2 million hectares

2011

5. Which Indian state possesses the highest proportion of area under saline soils primarily due to coastal and inland salinity?
(A) Gujarat
(B) Punjab
(C) Uttar Pradesh
(D) Rajasthan

2024

6. Acid soils in India are predominantly geographically distributed across which agro-ecological regions?
(A) North-Western semi-arid plains and central highlands of India
(B) Deccan plateau and the semi-arid tracts of central India
(C) Coastal plains and deltaic tracts of the western peninsular region
(D) Western Ghats, North-Eastern states, and Himalayan regions

2002

7. According to the United States Salinity Laboratory (USSL), a soil is classified as saline when its properties satisfy which of the following criteria?
(A) $EC < 4$ dS/m, $ESP > 15$, $pH > 8.5$
(B) $EC > 4$ dS/m, $ESP < 15$, $pH < 8.5$
(C) $EC > 4$ dS/m, $ESP > 15$, $pH > 8.5$
(D) $EC < 4$ dS/m, $ESP < 15$, $pH < 8.5$

2001

8. Analyze the assertion and reason statements below and select the correct option:
Assertion (A): Sodic soils exhibit poor physical structure, resulting in low infiltration rates.
Reason (R): High exchangeable sodium causes dispersion of soil colloids and degradation of aggregates.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.

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algae, and fungal growth within pipelines and emitters. Injecting low concentrations of chlorine periodically sanitizes the water flow. This chemical process kills organic organisms, prevents biofilm development, and decomposes organic matter, keeping the narrow emitter passages completely clear.

205. (C) 100 kg
To apply ten kilograms of actual nitrogen per hectare on a two-hectare plot, the total nitrogen required is twenty kilograms. Because the water-soluble fertilizer product contains twenty percent nitrogen, dividing twenty kilograms of nitrogen by zero point two indicates that exactly one hundred kilograms of the total fertilizer product must be dissolved.

206. (C) Inefficient, leading to leaching losses and groundwater pollution
Nitrate is a highly mobile anion in the soil because it is not adsorbed by clay particles. Applying all nitrogen at the beginning of the season provides far more nutrient than young plants can absorb. The excess nitrogen is carried downward by subsequent irrigations, leaching below the root zone and polluting groundwater.

207. (B) How easily a nutrient moves with water and leaches
Nutrient mobility in soil science describes the ease with which a chemical nutrient moves through the soil solution. Highly mobile nutrients, like nitrate, are not bound to soil colloids and move freely with soil water flow paths, whereas immobile nutrients, like phosphorus, are chemically bound and strongly resist downward leaching.

208. (D) Lower in fertigation due to immediate incorporation
When urea is broadcast on soil and flooded, substantial ammonia volatilization occurs as urea hydrolyzes near the warm, aerated soil surface. In contrast, drip fertigation applies urea solution directly into the subsurface wetted soil volume. This immediate movement of dissolved urea below the soil surface minimizes exposure to the atmosphere, reducing volatilization.

209. (A) Water flow rate of the main pipeline
A proportional fertigation pump is a water-driven dosing device that operates without external electrical power. It is plumbed directly into the main irrigation line. As the water flow rate through the pipeline increases or decreases, the internal mechanical piston strokes proportionally faster or slower, keeping the injected fertilizer concentration constant.

210. (C) In the middle phase, followed by a clear water flush
Fertigation scheduling is split into three distinct operational phases. During the first phase, clear water runs to pressurize the system and pre-wet soil. In the middle phase, fertilizer solution is injected. In the final phase, clear water runs

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2009

17. When applying iron pyrites (FeS_2) for sodic soil reclamation, a crucial prerequisite for its maximum efficiency is:
(A) Deep incorporation into the highly anaerobic and compacted soil zone
(B) Surface application under moist, well-aerated soil conditions
(C) Immediate flooding of the reclaimed field to dissolve the pyrite crystals
(D) Simultaneous application of high doses of agricultural grade lime

2006

18. What is the stoichiometric function of sulfuric acid when applied to calcareous sodic soils?
(A) It binds directly to exchangeable sodium, forming insoluble sodium sulfate complexes.
(B) It increases the soil pH to enhance the solubility and uptake of trace elements.
(C) It restricts the upward capillary rise of salts by forming a dense subsurface barrier.
(D) It dissolves native calcium carbonate to release soluble calcium.

2001

19. The physiological mechanism by which salt-tolerant plants prevent toxic ions from reaching the photosynthetic tissues is termed:
(A) Ion exclusion
(B) Osmotic adjustment
(C) Vacuolar compartmentalization
(D) Transpirational bypass

2002

20. Select the correct sequence of mechanisms utilized by halophytes for salt tolerance, ordered from external to internal cellular processes:
(A) Selective ion uptake → Root endodermis exclusion → Vacuolar compartmentalization
(B) Vacuolar compartmentalization → Selective ion uptake → Root endodermis exclusion
(C) Root endodermis exclusion → Vacuolar compartmentalization → Selective ion uptake
(D) Root endodermis exclusion → Selective ion uptake → Vacuolar compartmentalization

2024

21. Which organic molecule commonly functions as a compatible solute (osmoprotectant) in plants under salt stress?
(A) Proline
(B) Lignin
(C) Cellulose
(D) Starch

2017

22. In halophytes, the active transport of sodium ions into the vacuole to maintain low cytosolic sodium concentrations is primarily mediated by:
(A) Aquaporins
(B) Ca2+ ATPases
(C) Potassium outward rectifying channels
(D) Na+/H+ antiporters

2004

23. Which of the following field crops is generally classified as highly tolerant to soil salinity?
(A) Beans
(B) Barley
(C) Maize
(D) Onion

2022

24. A well-known alkali-tolerant rice variety developed specifically for sodic soil regions in India is:
(A) Pusa Basmati 1121
(B) IR 64
(C) CSR 10
(D) Swarna

2005

25. Consider the following characteristics used for selecting salt-tolerant crop varieties:
I. High potassium to sodium ($\frac{K^+}{Na^+}$) ratio in shoots
II. Early seedling vigor
III. Deep, highly branched root systems
IV. Increased stomatal conductance under stress
V. High synthesis rate of compatible osmolytes
Which of the above characteristics are desirable?
(A) I, II, III and V
(B) II, III, IV and V
(C) I, III and IV
(D) I, II and IV

2012

26. Which fruit crop demonstrates substantial tolerance to salinity and is suitable for degraded lands in semi-arid zones?
(A) Date palm
(B) Apple
(C) Papaya
(D) Strawberry

2007

27. Active soil acidity is quantitatively defined as the measure of hydrogen ion activity in the:
(A) Soil organic matter complex
(B) Soil solution
(C) Cation exchange sites

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groundwater buffers supply fluctuations, while diversifying toward low-water-demand crops reduces aggregate demand. Implementing high-efficiency micro-irrigation systems further minimizes field-level water waste, which directly helps stabilize declining regional freshwater subsurface groundwater aquifer storage resources.

185. (B) Accelerated soil erosion leading to reservoir siltation and reduced storage capacity
Removing forest cover in upper catchments exposes surface soils directly to rainfall impact. In the absence of tree roots and protective organic leaf litter, stormwater runoff accelerates soil erosion. The eroded sediment is transported downstream by rivers, settling in reservoirs and causing rapid siltation, which drastically reduces the water storage capacity.

186. (B) Design water discharge rate at the outlet per unit of culturable command area
In the warabandi canal system, water allowance represents a fundamental design parameter. It is defined as the continuous water discharge rate allocated at the outlet per unit of culturable command area, typically expressed in cusecs per thousand acres. This parameter determines the total quantity of water delivered to a command.

187. (A) Creation of local monopolies over water distribution by large landowners
Water User Associations are democratic, cooperative organizations established to improve equity and transparency in irrigation management. Successful associations resolve conflicts among water users, ensure a reliable water supply to tail-reach fields, and prevent powerful large landowners from establishing local water monopolies, thereby empowering the entire local farming community highly collectively.

188. (C) Regulation of inter-state rivers and valleys
Under the Constitution of India, water is a State subject under Entry seventeen of the State List, meaning states govern local water supplies. However, the Union Government has constitutional authority under Entry fifty-six of the Union List to regulate and develop inter-state rivers and river valleys to the extent declared by Parliament.

189. (B) 1956
The Inter-State River Water Disputes Act was enacted by the Parliament of India in nineteen fifty-six under Article two hundred and sixty-two of the Constitution. This Act provides the legal framework for resolving disputes relating to the waters of inter-state rivers and river valleys, enabling the establishment of specialized tribunals.

190. (C) Crop yield produced per unit volume of water consumed
Water productivity is a crucial metric for evaluating the efficiency of agricultural water management. It is calculated as the ratio of the total physical or economic crop yield produced to the total volume of water consumed or transpired by the crop, capturing how effectively water resources are converted into agricultural output.

191. (B) Groundwater depletion will accelerate due to zero marginal pumping costs.
Solar-powered pumps eliminate the ongoing fuel and electricity costs associated with pumping groundwater. In the absence of extraction limits, having zero marginal costs encourages continuous pumping. This leads to intensive, unregulated groundwater extraction, which accelerates the depletion of local aquifers and negates the water conservation benefits of other farm management practices.

192. (D) Public Trust Doctrine
The Public Trust Doctrine is a legal framework that treats vital resources like groundwater as common property held in trust by the state for the public. Applying this doctrine shifts water rights away from absolute land-linked ownership, enabling regulatory authorities to restrict private over-extraction and ensure sustainable, equitable distribution of resources.

193. (A) The Earth's rotation
The Coriolis force is an apparent force that deflects the path of moving objects, fluids, and winds within a rotating reference frame. It arises directly from the rotation of the Earth on its axis, deflecting currents to the right in the Northern Hemisphere and to the left in the Southern Hemisphere, shaping global circulation.

194. (C) Poor maintenance of tertiary channels and field channels
Although major water storage dams and canal networks are constructed successfully, the Command Area Development program often

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(A) Calcium hydroxide, oxygen, and carbon monoxide
(B) Calcium bicarbonate and pressurized hydrogen gas
(C) Calcium oxide and highly unstable carbonic acid
(D) Calcium ions, water, and carbon dioxide

2005

39. Upon sudden inundation and waterlogging, the redox potential (Eh) of a typical agricultural soil undergoes which sequential change?
(A) Rapid increase followed by stabilization above +500 mV
(B) Gradual decline from positive to negative values
(C) Immediate drop to -800 mV followed by a rapid rise
(D) Remains completely constant regardless of organic matter

2001

40. Consider the following statements regarding anaerobic nutrient transformations in waterlogged soils:
I. Nitrate is rapidly reduced to nitrogen gas via denitrification.
II. Manganic manganese ($Mn^{\{4+\}}$) is oxidized to more soluble forms.
III. Ferric iron ($Fe^{\{3+\}}$) is reduced to ferrous iron ($Fe^{\{2+\}}$), increasing its availability.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) II only
(C) I and III
(D) II and III

2001

41. In submerged soils, the production of methane gas is primarily associated with which specific biological condition?
(A) High soil redox potential maintained above +400 mV
(B) High nitrate concentrations in the soil solution suppressing methanogens
(C) Aerobic decomposition of surface crop residues in well-drained soils
(D) Extreme reduction and strict anaerobiosis ($Eh < -150$ mV)

2023

42. Following prolonged waterlogging, the increased availability of which element can frequently reach toxic concentrations for wetland crops like rice?
(A) Iron
(B) Copper
(C) Zinc
(D) Phosphorus

2019

43. The "critical water table depth" is defined agriculturally as the depth at which:
(A) Groundwater table depth where lateral flow permanently ceases in the aquifer
(B) Groundwater depth restricting aeration and reducing crop yield
(C) Groundwater table depth where upward capillary rise can no longer supply moisture
(D) Groundwater table depth where soluble salts are entirely leached below root zones

2017

44. A shallow water table typically restricts deep root development in mesophytic crops primarily due to:
(A) Excessive accumulation of essential macronutrients
(B) Depleted oxygen levels causing root suffocation
(C) Reduced thermal capacity of the soil profile
(D) Toxic accumulation of dissolved carbon dioxide

2014

45. Match the soil redox potential ranges (List I) with the predominant active electron acceptors (List II) in waterlogged soils.
List I: Soil redox potential ranges
P. +400 to +200 mV
Q. +200 to -100 mV
R. -100 to -200 mV
S. < -200 mV
List II: Predominant active electron acceptors
1. Carbon dioxide (methanogenesis)
2. Nitrate and Manganese
3. Iron
4. Sulfate
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-4, R-3, S-1
(D) P-1, Q-3, R-4, S-2

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2010

46. Capillary rise from a shallow, saline groundwater table exacerbates root zone salinity most severely under which climatic condition?
(A) Humid tropical climates characterized by high and continuous rainfall
(B) Cool temperate climates characterized by

heavy winter snowfall events
(C) Arid and semi-arid climates with high evaporative demand
(D) Sub-humid climates with evenly distributed precipitation

2014
47. Which mathematical or conceptual approach is typically used to estimate the contribution of shallow groundwater to crop evapotranspiration?
(A) Universal Soil Loss Equation (USLE)
(B) Penman-Monteith surface runoff equation
(C) Langmuir adsorption isotherm
(D) Darcy's Law for upward unsaturated flow

2023
48. In soils with a shallow water table, upward capillary flux is generally greatest in which soil textural class?
(A) Coarse sand
(B) Heavy clay
(C) Silt loam
(D) Gravel

2017
49. The use of lysimeters in problematic soil management is directly associated with the precise measurement of:
(A) Soil structural stability, aggregate dispersion, and surface crust strength
(B) Crop evapotranspiration and deep percolation
(C) Active, reserve, and exchangeable soil acidity components
(D) Trace metal bioaccumulation and concentration in plant leaves

2010
50. Analyze the assertion and reason statements below and select the correct option:
Assertion (A): Over-extraction of groundwater in agricultural watersheds frequently leads to aquifer depletion.
Reason (R): The rate of groundwater withdrawal exceeds the natural recharge capacity of the aquifer system.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002
51. Excessive canal seepage in unlined irrigation networks primarily contributes to which hydrological imbalance?
(A) Localized waterlogging and salinization
(B) Depletion of deep aquifers
(C) Increased velocity of surface runoff
(D) Reduction in soil moisture retention capacity

2009
52. Managed Aquifer Recharge (MAR) is a corrective hydrological measure that aims to:
(A) Enhance surface drainage network systems discharging into ocean basins
(B) Extract highly saline groundwater to supply desalinization plants
(C) Replenish groundwater resources using excess surface water
(D) Seal aquifer boundaries to prevent any vertical water exchange

2019
53. Which engineering structure is specifically designed to facilitate artificial groundwater recharge in semi-arid watersheds?
(A) Percolation tanks
(B) Tile drains
(C) Mole drains
(D) Embankment levees

2025
54. The salinity hazard of irrigation water is standardly expressed by measuring its:
(A) Residual Sodium Carbonate (RSC)
(B) Total Suspended Solids (TSS)
(C) Sodium Adsorption Ratio (SAR)
(D) Electrical Conductivity (EC)

2009
55. The Sodium Adsorption Ratio (SAR) of irrigation water evaluates the relative concentration of sodium compared to which specific ions?
(A) Potassium and Chloride
(B) Calcium and Magnesium
(C) Iron and Manganese
(D) Carbonate and Bicarbonate

2017
56. Residual Sodium Carbonate (RSC) in irrigation water is mathematically calculated using which formula?
(A) $(Na^{+} + K^{+}) - (Ca^{\{2+\}} + Mg^{\{2+\}})$
(B) $\left(Cl^{-} + SO_4^{\{2-\}}\right) - (Na^{+} + K^{+})$
(C) $\left(CO_3^{\{2-\}} + HCO_3^{-}\right) - (Ca^{\{2+\}} + Mg^{\{2+\}})$

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(D) $\frac{Ca^{2+} + Mg^{2+}}{CO_3^{2-} + HCO_3^-}$

2010

57. According to standard irrigation water quality guidelines, water with an RSC value greater than 2.5 meq/L is generally considered:
(A) Safe for all crops without restrictions
(B) Marginally safe requiring occasional gypsum application
(C) Excellent for reclaiming existing saline soils
(D) Unsuitable for irrigation due to severe alkali hazard

2004

58. Based on the USSL classification, irrigation water designated as C_3-S1 indicates:
(A) High salinity and low sodium hazard
(B) Low salinity and low sodium hazard
(C) Low salinity and high sodium hazard
(D) High salinity and high sodium hazard

2015

59. When utilizing brackish irrigation water, the strategy of cyclic or alternating use refers to:
(A) Mixing brackish water and fresh water in a reservoir prior to field-scale application
(B) Using fresh water for sensitive and brackish for tolerant growth stages
(C) Irrigating crops with brackish water exclusively during the cooler nighttime hours
(D) Using brackish water resources exclusively during high-rainfall monsoon seasons

2006

60. Consider the following statements regarding the agronomic management of brackish water:
I. Micro-irrigation systems decrease the adverse effects of brackish water compared to flood irrigation.
II. Frequent, light irrigations help maintain high soil matrix potential and low salt concentration.
III. Application of organic manures exacerbates the salinity hazard of brackish water.
IV. Pre-sowing irrigation with fresh water improves germination rates.
Which of the above statements is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I and II

2001

61. The "Leaching Requirement" (LR) is defined mathematically as the fraction of applied irrigation water that must pass through the root zone to:
(A) Maintain soil salinity at a tolerable level for crops
(B) Completely dissolve and leach out all native primary soil minerals
(C) Elevate the underlying groundwater table directly to the root interface
(D) Prevent any downward vertical leaching movement of nitrate fertilizers

2011

62. Which formulation is commonly utilized to estimate the Leaching Requirement (LR)?
(A) $LR = \frac{EC_e \times EC_w}{100}$
(B) $LR = \frac{SAR_w}{EC_w}$
(C) $LR = \frac{EC_w}{5 \times EC_e - EC_w}$
(D) $LR = \frac{EC_e}{EC_w}$

2001

63. Contingent crop planning for chronically flood-prone areas primarily relies on selecting crop varieties that possess:
(A) Extreme tolerance to prolonged drought conditions
(B) Shallow, highly restricted root system architecture
(C) Extreme sensitivity to daily photoperiod changes
(D) Submergence tolerance and elongation

2001

64. A key agronomic strategy to manage crops immediately following the recession of floodwaters is:
(A) Deep mechanical plowing to invert the compacted soil profile completely
(B) Immediate flooding with high-quality fresh water to leach residual salts
(C) Minimum tillage planting of short-duration crops
(D) Withholding all mineral nutrient applications until the following season

2013

65. The cultivation of deepwater rice is uniquely adapted to flood-prone areas due to its physiological ability to:
(A) Rapidly transport dissolved oxygen from roots directly to aerial leaves
(B) Elongate internodes rapidly to keep foliage

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affected environments and severely restricts crop yields?
(A) Copper
(B) Molybdenum
(C) Boron
(D) Zinc

2013
105. In the context of acid soil management, what does the term "over-liming" commonly induce?
(A) Severe aluminum toxicity
(B) Enhanced availability of all micronutrients
(C) Rapid decrease in soil pH
(D) Micronutrient deficiencies

2009
106. A key physiological symptom of true submergence stress (as opposed to mere waterlogging) in plants is:
(A) Rapid desiccation of leaf margins
(B) Accelerated rate of aerobic respiration
(C) Depletion of carbohydrate reserves
(D) Accumulation of toxic levels of nitrates in leaves

2014
107. Which soil amendment is frequently utilized alongside gypsum to improve its solubility and the overall reclamation efficiency in calcareous sodic soils?
(A) Sodium chloride
(B) Anhydrous ammonia
(C) Basic slag
(D) Green manure

2005
108. The concept of "capillary fringe" above a shallow water table refers to the zone where:
(A) Saturated soil under negative pressure
(B) Dry soil with high aeration capacity
(C) Saturated soil under positive pressure
(D) Saturated soil with high horizontal flow

2018
109. Inland aquaculture of whiteleg shrimp (L. vannamei) in saline groundwater often requires artificial supplementation of which deficient mineral?
(A) Sodium
(B) Potassium
(C) Chloride
(D) Sulfate

2017
110. Match the crop species (List I) with their generally classified relative salt tolerance levels (List II).
List I: (Crop species)
P. Cotton
Q. Wheat
R. Beans
S. Sugarbeet
List II: (Relative salt tolerance levels)
1. Highly Tolerant
2. Tolerant
3. Moderately Tolerant
4. Sensitive
(A) P-1, Q-4, R-2, S-3
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-4, R-3, S-1

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2016
111. Which method provides a rapid, non-destructive field estimation of bulk soil electrical conductivity?
(A) Electromagnetic induction
(B) Flame photometry
(C) Atomic absorption spectroscopy
(D) Silver nitrate titration

2025
112. At what approximate pH level does the solubility of iron and aluminum oxides increase drastically, causing potential toxicity in soils?
(A) > 8.5
(B) 7.0 - 7.5
(C) < 5.0
(D) 6.0 - 6.5

2015
113. The most critical constraint for crop survival in chronically flood-prone deepwater ecosystems is:
(A) Lack of adequate fresh water supply
(B) Lack of sufficient solar radiation
(C) Extremely high soil temperatures
(D) Low dissolved oxygen in floodwater

2023
114. For the efficient operation of a tile drainage system, a gravel envelope or synthetic filter wrapped around the pipe is necessary to:
(A) Increase the soil acidity surrounding the drainage pipe
(B) Act as a chemical barrier against soluble soil salts
(C) Prevent fine soil particles from clogging the drain
(D) Accelerate the upward capillary movement

Q. Silvipastoral system
R. Agroforestry
S. Aquaculture integration

List II: Primary functional definitions

1. Integrating woody perennials with forage crops and livestock
2. Growing specialized salt-accumulating plants for economic use
3. Rearing aquatic organisms in constructed ponds using brackish water
4. Combining agricultural crops with protective tree plantations

(A) P-2, Q-1, R-4, S-3
(B) P-3, Q-1, R-2, S-4
(C) P-1, Q-4, R-3, S-2
(D) P-2, Q-4, R-1, S-3

2013

76. Salicornia species are considered highly suitable for which alternate land-use system on severely salt-affected soils?
(A) Commercial silviculture practices for timber extraction
(B) Halophyte cultivation for oil and biomass
(C) Green manuring strategies for biological acid soil reclamation
(D) Intensive aerobic rice farming under dryland conditions

2001

77. In silvipastoral systems designed for sodic soils, which grass species is recognized as a highly tolerant pioneer colonizer?
(A) Leptochloa fusca
(B) Cenchrus ciliaris
(C) Panicum maximum
(D) Zea mays

2012

78. Inland saline water aquaculture fundamentally involves utilizing degraded agricultural lands and saline groundwater to cultivate:
(A) Cold-water trout species in elevated upland areas
(B) Sensitive freshwater carp species grown exclusively
(C) Salt-tolerant fish and shrimp
(D) Deep-sea marine corals in offshore artificial reefs

2008

79. The Pacific white shrimp (Litopenaeus vannamei) is widely adopted in inland saline farming due to its specific capacity for:
(A) Surviving completely out of water under high relative humidity for extended periods
(B) Fixing dissolved atmospheric nitrogen to assist primary producers and aquatic plants
(C) Reproducing rapidly and asexually within heavily enclosed high-salinity ponds
(D) Tolerating wide salinity fluctuations

2008

80. Consider the following constraints impacting inland saline shrimp farming:
I. Ionic imbalances in groundwater, particularly low potassium and magnesium.
II. Excessive accumulation of toxic ammonia and nitrites in pond water.
III. Rapid seepage losses in highly permeable sandy soils.
IV. Requirement for high-cost artificial feeds.
V. Absolute dependence on fresh water for daily pond flushing.

Which of the above constraints is/are INCORRECT?
(A) I and II
(B) III and IV
(C) V only
(D) I, II and IV

2001

81. A critical soil physical property that determines the feasibility of constructing inland aquaculture ponds in degraded soils is:
(A) Extremely high hydraulic conductivity values across all soil horizons
(B) Sufficient clay to retain water and minimize seepage
(C) Presence of a shallow, highly permeable sandy layer within the subsurface
(D) Total and absolute absence of any biological organic matter components

2002

82. The application of chemical amendments like gypsum to highly sodic soils improves hydraulic conductivity by:
(A) Clogging active macropores with thick layer of insoluble chemical precipitates
(B) Dissolving all existing silicate clay minerals present in the topsoil
(C) Increasing the exchangeable sodium percentage of the soil exchange complex
(D) Flocculating clay particles and enhancing soil structure

2022

83. The toxic effect of sodium on plant metabolism is predominantly due to its competitive interference

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with the cellular uptake and function of which essential ion?
(A) Potassium
(B) Iron
(C) Phosphorus
(D) Sulfur

2001
84. Which parameter is considered the most reliable indicator of the true salinity stress experienced by a crop in the field?
(A) Electrical conductivity of the irrigation water (EC_w)
(B) Total soluble solids of the dry soil
(C) EC of the soil saturation extract (EC_e)
(D) Sodium adsorption ratio of the drainage water

2009
85. Calcareous soils, though rarely highly acidic, present a problematic nutritional environment primarily characterized by the severe deficiency of:
(A) Iron, Zinc, and Phosphorus
(B) Calcium, Magnesium, and Carbon
(C) Sodium, Chloride, and Silicon
(D) Molybdenum, Sulfur, and Boron

2005
86. Which reclamation strategy is LEAST appropriate for managing an actively waterlogged, heavy clay soil?
(A) Installation of subsurface tile drains
(B) Construction of raised beds and furrows
(C) Cultivation of deep-rooted, high-transpiration tree species
(D) Continuous application of heavy flood irrigation

2016
87. Under high pH conditions ($pH > 8.5$) typical of sodic soils, the volatilization loss of which applied macronutrient is significantly accelerated?
(A) Phosphorus (as phosphine gas)
(B) Nitrogen (as ammonia gas)
(C) Potassium (as potassium oxide)
(D) Calcium (as calcium vapor)

2013
88. A common biological indicator species naturally found thriving in undisturbed, highly alkaline (sodic) soils in northern India is:
(A) Mangifera indica
(B) Camellia sinensis
(C) Prosopis juliflora
(D) Hevea brasiliensis

NODIA

2003
89. In the context of acid sulfate soils, the drastic drop in pH upon artificial drainage and aeration is caused by the oxidation of:
(A) Calcium carbonate
(B) Aluminum oxides
(C) Soil organic matter
(D) Iron sulfides

2022
90. Analyze the assertion and reason statements below and select the correct option:
Assertion (A): Application of basic slag is an effective practice for reclaiming acid soils and improving crop yields.
Reason (R): Basic slag contains silicates and calcium which neutralize acidity, and it provides a supplementary source of phosphorus.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006
91. The determination of Exchangeable Sodium Percentage (ESP) requires the quantification of exchangeable sodium and the:
(A) Total concentration of soluble salts
(B) Cation Exchange Capacity (CEC)
(C) Anion Exchange Capacity (AEC)
(D) Total soil bulk density value

2008
92. Which soil order (USDA taxonomy) is most commonly associated with naturally occurring, highly weathered acid soils of tropical regions?
(A) Aridisols
(B) Oxisols
(C) Mollisols
(D) Vertisols

2005
93. Conjunctive use of water in agricultural water management implies:
(A) Integrating surface water and groundwater resources to optimize availability
(B) Using surface water exclusively during high-flow periods of the monsoon season
(C) Restricting irrigation strictly to critical physiological crop growth stages
(D) Applying high-quality fresh water and chemical fertilizers simultaneously

2005

94. The Sub1A gene incorporated into certain modern rice varieties specifically confers tolerance to:
(A) High soil salinity
(B) Extreme aluminum toxicity
(C) Complete submergence
(D) Severe drought conditions

2025

95. The phenomenon where high sodium concentrations induce soil aggregates to break down into individual primary particles is termed:
(A) Flocculation
(B) Cementation
(C) Illuviation
(D) Dispersion

2011

96. Which factor most directly exacerbates manganese toxicity in strongly acidic soils?
(A) Application of agricultural lime
(B) High levels of organic matter decomposition
(C) Waterlogging and reducing conditions
(D) Inoculation with nitrogen-fixing bacteria

2017

97. What is the fundamental difference between active acidity and exchangeable acidity?
(A) Active acidity is due to $Al^{\{3+\}}$, while exchangeable is due to H^{+}.
(B) Active acidity is in soil solution; exchangeable is on colloids.
(C) Active acidity can only be neutralized by organic matter, unlike exchangeable acidity.
(D) Active acidity is measured in meq/100g, while exchangeable acidity is measured only in pH.

2023

98. When selecting trees for bio-drainage, deep rooting is essential primarily because it allows the tree to:
(A) Anchor firmly against extremely strong, high-velocity hurricane winds
(B) Access deep subsurface reserves of otherwise trapped atmospheric oxygen
(C) Prevent the downward vertical leaching percolation of toxic heavy metals
(D) Extract moisture from the capillary fringe of the water table

2016

99. The efficiency of a subsurface drainage system is heavily dependent on the soil's:
(A) Hydraulic conductivity
(B) Particle density
(C) Specific heat capacity
(D) Cation exchange capacity

2017

100. Consider the following statements regarding specific ion toxicities:
I. Boron toxicity is common in soils irrigated with poor quality water in arid regions.
II. Chloride toxicity symptoms typically first appear on younger, actively growing leaves.
III. Sodium toxicity directly impairs the structural integrity of chloroplasts.
Which of the above statements is/are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I only

2005

101. During the reclamation of saline soils, leaching must be accompanied by which essential physical prerequisite?
(A) Adequate subsurface drainage to remove the leachate
(B) Complete and absolute biological removal of all organic matter
(C) High levels of mechanical soil compaction on the surface layer
(D) Artificial elevation of the overall soil pH to values above 9.0

2014

102. Which metric characterizes the relative hazard of bicarbonate in irrigation water precipitating calcium and magnesium?
(A) Sodium Adsorption Ratio
(B) Soluble Sodium Percentage
(C) Permeability Index
(D) Residual Sodium Carbonate

2002

103. The primary reason for blending saline water with fresh water for irrigation is to:
(A) Increase the overall dissolved mineral nutrient content of the fresh water supply
(B) Reduce net salinity below the crop tolerance threshold
(C) Eliminate all specific toxic ionic species completely from the water solution
(D) Increase the overall physical temperature of the applied irrigation water

2005

104. Which trace element, while essential in minute quantities, often reaches toxic levels in salt-

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above rising water
(C) Halt all vegetative metabolic processes entirely until the floodwater recedes
(D) Absorb inert atmospheric nitrogen directly through its submerged leaves

2021
66. In the context of flood-affected regions, what is the defining characteristic of "boro rice" cultivation?
(A) It is cultivated strictly during the peak monsoon season under deep standing water.
(B) It is a traditional dryland rice variety grown strictly without any supplemental irrigation.
(C) It is an upland rice variety seeded directly prior to the actual onset of the monsoon.
(D) It is grown in winter/spring using residual moisture after floods recede.

2007
67. Adaptive crop calendars in flood-prone environments often shift the planting dates to:
(A) Escape the historically most probable period of inundation
(B) Ensure the crop vegetative stage coincides exactly with peak flooding
(C) Maximize exposure to cold winter temperatures
(D) Align harvesting with the onset of heavy pre-monsoon showers

2008
68. The primary objective of an agricultural subsurface drainage system is to:
(A) Remove excess surface ponding and runoff immediately after heavy rainfall events
(B) Prevent physical water erosion of topsoil by stabilizing field contour banks
(C) Lower the water table and facilitate salt leaching
(D) Provide critical supplemental irrigation water during prolonged dry weather periods

2008
69. Mole drains are most effective and durable when installed in which specific type of soil profile?
(A) Heavy clay soils with high structural stability
(B) Coarse, sandy soils with low cohesion
(C) Peaty organic soils with high subsidence rates
(D) Shallow soils overlying dense bedrock

2009
70. The "drainage coefficient" is a critical design parameter defined as the:
(A) Percentage of total seasonal rainfall that successfully infiltrates the soil profile
(B) Ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity of soil
(C) Spacing distance required between parallel subsurface drain pipes in a field
(D) Depth of water removed from the drainage area in 24 hours

2018
71. In the design of subsurface tile drainage systems, Hooghoudt's equation is extensively utilized to calculate the:
(A) Standard internal diameter of the corrugated drainage pipes
(B) Optimal spacing between lateral drains
(C) Exact depth of the underlying impermeable clay soil layer
(D) Required mechanical horsepower for the electrical drainage pump

NODIA

2015
72. Which material is currently most prevalent worldwide for the construction of corrugated subsurface drainage pipes?
(A) Baked clay tiles
(B) Cast iron
(C) Perforated PVC or PE
(D) Reinforced concrete

2022
73. Bio-drainage mitigates waterlogging through which primary biophysical mechanism?
(A) Enhanced surface runoff and evaporation losses via dense canopy interception
(B) Physical compaction and restructuring of the deep soil profile by tree roots
(C) Chemical precipitation and immobilization of dissolved salts in the rhizosphere
(D) Transpirational withdrawal of groundwater by deep-rooted trees

2010
74. Which tree species is most widely recommended and utilized for bio-drainage in waterlogged areas of India due to its high transpiration rate?
(A) Eucalyptus species
(B) Teak (Tectona grandis)
(C) Neem (Azadirachta indica)
(D) Pine (Pinus roxburghii)

2013
75. Match the alternate land-use systems (List I) with their primary functional definitions (List II) for degraded lands.
List I: Alternate land-use systems
P. Halophyte cultivation

of soil water

2002

115. A prominent feature distinguishing saline-sodic soils from purely saline soils is that upon continuous leaching with pure water:
(A) Drastic decrease in soil pH to highly acidic levels
(B) Transition into sodic soils with degraded structure
(C) Immediate transformation into highly productive soils
(D) Natural reduction of exchangeable sodium percentage to zero

2023

116. Which chemical reaction correctly represents the neutralization of active acidity by calcium carbonate?
(A) $CaCO_3 + H_2O \rightarrow Ca(OH)_2 + CO_2$
(B) $CaCO_3 + Al^{3+} \rightarrow CaAl + CO_3^{2-}$
(C) $CaCO_3 + 2Na^+ \rightarrow Na_2CO_3 + Ca^{2+}$
(D) $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + H_2O + CO_2$

2003

117. In areas suffering from secondary salinization due to canal irrigation, the primary driver of the problem is usually:
(A) Rising water tables due to inadequate drainage
(B) Inherently high salt content of canal water
(C) Lack of organic manure application in fields
(D) Cultivation of salt-tolerant crop varieties

2009

118. Which plant family contains the highest number of recognized extreme halophyte species suitable for alternate land use on saline soils?
(A) Fabaceae
(B) Poaceae
(C) Amaranthaceae (including Chenopodiaceae)
(D) Rosaceae

2013

119. A major advantage of adopting a silvipastoral system on degraded sodic lands is that the deep-rooted trees:
(A) Improve soil drainage via root penetration and add organic matter
(B) Translocate and pump excess salts directly to the soil surface
(C) Provide a highly robust physical barrier against regional floods
(D) Consume all available nitrogen to suppress understory weed growth

2008

120. Consider the following statements regarding the physiological effects of waterlogging on plants:
I. Reduced oxygen availability inhibits root aerobic respiration.
II. Accumulation of ethylene in plant tissues promotes aerenchyma formation.
III. Stomatal conductance usually increases to compensate for root stress.
IV. Uptake of essential macronutrients like N, P, and K is severely restricted.
Which of the above statements are correct?
(A) II, III and IV
(B) I, III and IV
(C) I and II
(D) I, II and IV

2024

121. The term "black alkali" historically refers to sodic soils primarily because:
(A) They contain high concentrations of dark volcanic ash
(B) Dissolved organic matter deposits as a dark surface crust
(C) They possess exceptionally high levels of manganese oxides
(D) They are completely devoid of any light-colored minerals

2015

122. Under strictly anaerobic conditions in waterlogged soils, the biological reduction of sulfate results in the formation of:
(A) Sulfuric acid
(B) Elemental sulfur
(C) Hydrogen sulfide gas
(D) Sulfur dioxide

2016

123. The quantity of gypsum required to reclaim a sodic soil depends most directly upon the soil's initial ESP and its:
(A) Active soil acidity
(B) Sand fraction content
(C) Total soil porosity
(D) Cation exchange capacity

2012

124. Which index evaluates the risk of irrigation water reducing soil permeability, utilizing sodium, calcium, magnesium, and bicarbonate concentrations?
(A) Permeability Index (PI)
(B) Kelly's Ratio
(C) Langelier Saturation Index
(D) Magnesium Hazard Index

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2006

145. The physiological adaptation termed "aerenchyma" helps wetland plants survive waterlogging by:
(A) Storing large volumes of fresh water within specialized cortical cells
(B) Secreting toxic soluble salts directly into the surrounding water
(C) Increasing root physical density to anchor against strong currents
(D) Providing an internal pathway for oxygen diffusion from shoots to roots

2013

146. Which agronomic practice is most advisable for establishing a crop in a mildly saline field?
(A) Deep sowing of seeds to reach moisture
(B) Applying minimal irrigation to concentrate salts
(C) Increasing the standard seed rate by 20-25%
(D) Completely avoiding the use of organic manures

2015

147. A "solonetz" is the pedological classification equivalent to which of the following problematic soils?
(A) Saline soil
(B) Sodic (alkali) soil
(C) Acid soil
(D) Peat soil

2016

148. Hydrological imbalances causing groundwater depletion in hard-rock aquifers are uniquely challenging because these aquifers typically possess:
(A) Extremely high specific yield and rock porosity
(B) Rapid and unchecked intrusion of coastal seawater
(C) Spontaneous and continuous artesian upwelling
(D) Low storage capacity and slow recharge rates

2018

149. The measurement of Exchangeable Aluminum ($Al^{\{3+\}}$) in acid soils is typically accomplished by extracting the soil with:
(A) 1 N Potassium Chloride
(B) 1 N Ammonium Acetate (pH 7.0)
(C) 0.5 M Sodium Bicarbonate
(D) Distilled water

2010

150. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In saline soils, crops frequently suffer from physiological drought despite the soil appearing moist.
Reason (R): High concentrations of soluble salts significantly lower the osmotic potential of the soil solution, restricting root water uptake.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2011

151. Which irrigation method is broadly considered the most efficient for utilizing saline water, as it maintains high soil matric potential and minimizes foliar salt absorption?
(A) Drip (trickle) irrigation
(B) Sprinkler irrigation
(C) Border strip irrigation
(D) Wild flooding

2024

152. The USSL diagram for classifying irrigation water plots Sodium Adsorption Ratio (SAR) on the vertical axis against which parameter on the horizontal axis?
(A) pH
(B) Residual Sodium Carbonate (RSC)
(C) Boron concentration
(D) Electrical Conductivity (EC)

NODIA

2009

153. A high concentration of sodium in irrigation water negatively impacts soil permeability by:
(A) Flocculating clay particles into stable granules
(B) Causing swelling and dispersion of 2:1 lattice clays
(C) Rapidly dissolving quartz minerals
(D) Promoting the massive proliferation of soil fungi

2010

154. Under high salinity stress, plants frequently exhibit a decreased shoot-to-root ratio. This is primarily because:
(A) Stimulation of root system growth by chloride ions
(B) Active attempt of the plant to maximize leaf area

(A) Improved root zone aeration above the saturated layer
(B) Complete elimination of capillary rise in soil profile
(C) Increased waterlogging in the furrows for dryland crops
(D) Complete elimination of the need for chemical fertilizers

2025
136. Inland saline aquaculture differs crucially from coastal brackish water aquaculture because inland saline groundwater often:
(A) Displays an ionic composition identical to standard seawater
(B) Contains extremely high levels of dissolved oxygen
(C) Is completely devoid of dissolved carbon dioxide gas
(D) Exhibits significant deficiencies in potassium and calcium

2018
137. White alkali soils are characterized by the predominant surface accumulation of which specific salts?
(A) Sodium carbonates, bicarbonates, and hydroxides
(B) Chlorides and sulfates of sodium, calcium, and magnesium
(C) Iron, aluminum, and hydrogen sulfates in acid soils
(D) Calcium, magnesium, and potassium carbonates

2021
138. The process of denitrification in waterlogged soils results in the loss of nitrogen primarily in the form of:
(A) Gaseous ammonia (NH_3) volatilization
(B) Soluble nitrate (NO_3^-) leaching losses
(C) Nitrous oxide (N_2O) and dinitrogen (N_2) gases
(D) Insoluble organic nitrogen complex formation

2014
139. In highly weathered acid soils (Oxisols and Ultisols), the dominant clay minerals typically possess:
(A) High permanent negative charge
(B) Expansive 2:1 lattice structures
(C) Zero cation exchange capacity
(D) Variable, pH-dependent charge

2024
140. Consider the following criteria used to evaluate the quality of liming materials:
I. Chemical purity
II. Neutralizing value (CCE)
III. Fineness or particle size
IV. Moisture content
V. Cation exchange capacity of the lime
Which of the above criteria are strictly relevant for determining liming effectiveness?
(A) I, II, III and IV
(B) II, III, IV and V
(C) I, II and III
(D) I, III and V

2023
141. The rate of reaction of agricultural limestone in neutralizing soil acidity increases significantly as the:
(A) Particle size of the limestone increases
(B) Particle size of the limestone decreases
(C) Soil temperature drops to freezing point
(D) Soil moisture drops to permanent wilting point

2005
142. A typical diagnostic symptom of iron toxicity in flooded rice fields, common in acid sulfate or highly reduced soils, is known as:
(A) White tip disease
(B) Bronzing of the leaves
(C) Khaira disease
(D) Blast lesioning

2018
143. Which drainage system relies on unlined, subsurface cylindrical channels formed directly in the cohesive clay subsoil using a specialized implement?
(A) Mole drainage
(B) Tile drainage
(C) Interceptor drainage
(D) Vertical drainage

2004
144. In coastal agro-ecosystems experiencing tidal inundation, which specific soil type often forms when mangrove swamps are drained for agriculture?
(A) Calcareous soils
(B) Sodic soils
(C) Acid sulfate soils
(D) Peat bogs

NODIA

2011

125. The cultivation of Dhaincha (Sesbania aculeata) prior to rice in sodic soils acts as an excellent reclamation strategy primarily due to its:
(A) Extremely deep roots that secrete highly alkaline organic compounds
(B) High pH tolerance, nitrogen fixation, and acidic biomass addition
(C) High transpirational water use that rapidly depletes groundwater
(D) Selective absorption and permanent storage of sodium in stem wood

2014

126. An essential management practice to minimize the adverse effects of saline irrigation water on seed germination is to:
(A) Sow seeds on the top center of a single-row raised bed
(B) Sow seeds on the sloping side of the ridge
(C) Broadcast seeds randomly over a flat, unplowed surface
(D) Delay sowing until the peak of the dry season

2025

127. Excessive accumulation of exchangeable magnesium in certain problematic soils can lead to:
(A) Soil dispersion and degraded physical structure
(B) Enhanced soil flocculation and improved drainage
(C) Drastic reduction in overall soil pH values
(D) Enhanced biological fixation of atmospheric nitrogen

2006

128. What is the fundamental principle behind using specific ion microelectrodes in soil chemistry?
(A) Measuring the total mass of soluble salts in soil
(B) Determining the precise size distribution of clay
(C) Measuring the electrochemical activity of a specific ion
(D) Evaluating the total organic carbon content of soil

2018

129. The term "osmotic adjustment" in salt-tolerant plants refers directly to the:
(A) Physical shrinkage of the cell wall to prevent water loss
(B) Complete exclusion of all toxic ions at the root surface
(C) Rapid shedding of older leaves to reduce transpirational area
(D) Intracellular solute accumulation to maintain cell turgor

2003

130. Among the following, which fertilizer is LEAST recommended for application in highly acidic soils due to its strong residual acid-forming nature?
(A) Calcium ammonium nitrate
(B) Single superphosphate
(C) Ammonium sulfate
(D) Potassium chloride

2006

131. In the estimation of shallow groundwater contribution to crop water requirement, the upward flux primarily depends on the water table depth and the:
(A) Crop canopy cover
(B) Soil hydraulic conductivity characteristics
(C) Atmospheric carbon dioxide concentration
(D) Soil organic matter content

2017

132. Phosphorus fixation in strongly alkaline, calcareous soils is dominated by the formation of relatively insoluble:
(A) Iron phosphates
(B) Aluminum phosphates
(C) Magnesium phosphates
(D) Calcium phosphates

2021

133. Which parameter is critical for identifying potential boron toxicity in irrigation water?
(A) Concentrations exceeding 1-2 mg/L (ppm)
(B) Concentrations exceeding 50 mg/L (ppm)
(C) Complete absence of boron
(D) Boron strictly in the form of boric acid

2011

134. Boro rice cultivation relies heavily on:
(A) Utilizing seasonal rainfed moisture during the monsoon
(B) Utilizing tidal inundations in low-lying coastal areas
(C) Utilizing groundwater or surface water in dry winter
(D) Utilizing snowmelt runoff water in alpine regions

2019

135. When managing soils with a shallow water table, a key advantage of adopting a furrow-irrigated raised bed (FIRB) planting system is:

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(C) Higher sensitivity of shoots than roots to salinity
(D) Immediate death of all roots on contact with salt

2009

155. Which of the following is considered an indirect, biological method for reclaiming mild to moderately sodic soils?
(A) Application of concentrated sulfuric acid to the soil
(B) Continuous pumping of saline groundwater onto the field
(C) Intensive deep plowing using heavy farm machinery
(D) Cultivation of deep-rooted, acid-exuding grasses

2004

156. The specific toxicity of the chloride ion in woody perennial crops usually manifests first as:
(A) Leaf tip burn and marginal necrosis
(B) Stunted root tips
(C) Sudden dropping of all unripe fruit
(D) Dark green, leathery leaves

2001

157. During the reclamation of saline-sodic soils, why is it disastrous to leach the soil with low-salinity water before adding a calcium amendment?
(A) It creates extreme soil acidity by releasing hydrogen ions.
(B) Removing soluble salts causes exchangeable sodium to disperse the soil.
(C) It rapidly elevates the overall salt concentration in groundwater.
(D) It kills all beneficial soil microorganisms and bacteria instantly.

2015

158. The phenomenon of "specific ion effect" in salt-stressed plants refers to:
(A) Generalized physical difficulty of extracting water from saline soil
(B) Nutritional imbalance and direct toxicity from specific ions
(C) Rapid stomatal closure triggered by abscisic acid synthesis
(D) Selective absorption of necessary plant nutrients from the soil

2014

159. When dealing with waterlogged, flood-prone areas, the term "contingent crop planning" specifically means:
(A) Alternative cropping strategies based on flood timing and duration
(B) Planned permanent abandonment of agricultural activities in the region
(C) Exclusive cultivation of highly water-sensitive commercial crops
(D) Complete reliance on external government food distribution programs

NODIA

2019

160. Which of the following amendments is best suited for reducing soil pH in highly calcareous soils to improve micronutrient availability?
(A) Calcium carbonate
(B) Basic slag
(C) Elemental sulfur
(D) Sodium nitrate

2001

161. In soils subjected to prolonged waterlogging, the reduction of iron and manganese can lead to their rapid leaching. Upon subsequent drainage and aeration, these elements often:
(A) Evaporate completely from the topsoil profile
(B) Remain completely soluble in water indefinitely
(C) Bind irreversibly with organic soil nitrogen
(D) Precipitate as mottles and concretions in the profile

2009

162. The standard method for measuring soil pH of salt-affected soils requires preparing a soil-water suspension, most commonly in the ratio of:
(A) 1:10
(B) 1:100
(C) 1:1 or 1:2.5
(D) 10:1

2008

163. The integration of agroforestry in problematic environments primarily assists in reclamation through:
(A) Maximizing the reflection of solar radiation (albedo)
(B) Biodrainage, nutrient cycling, and organic matter addition
(C) Eliminating the need for any artificial drainage structures
(D) Increasing the soil bulk density drastically

2013

164. In heavily leached, tropical acid soils, the capacity of the soil to hold and exchange anions (Anion Exchange Capacity) is primarily provided by:
(A) Humic acid

29. (A) Intense leaching of basic cations by high rainfall
Natural genesis of acid soils in humid tropical regions is driven by high rainfall. Excessive precipitation percolates through the soil profile, leaching away soluble basic cations like calcium, magnesium, and potassium. This depletion leaves the exchange complex dominated by acidic aluminum and hydrogen ions, which hydrolyze to release protons, progressively lowering the soil pH.

30. (A) Both A and R are true and R is the correct explanation of A.
Aluminum toxicity is a primary growth-limiting factor in strongly acidic soils. When the soil pH drops below 5.5, the solubility of aluminum-bearing clay minerals increases dramatically. This dissolution releases phytotoxic trivalent aluminum ions into the soil solution. These active ions inhibit root cell division and elongation, preventing normal nutrient and water uptake.

31. (D) Hydrogen and Aluminum
Exchangeable acidity refers to the fraction of soil acidity held on the electrostatic exchange sites of clay minerals and organic matter. This component is predominantly composed of exchangeable hydrogen and monomeric aluminum ions. When these cations are displaced into the soil solution by neutral salts, they hydrolyze, releasing hydronium ions that lower the measured pH.

32. (C) Iron and aluminum oxides
Phosphorus availability in highly acidic soils is severely restricted by chemical fixation. At low pH, soluble orthophosphate ions react with active iron and aluminum oxides present on soil colloids. This reaction forms highly insoluble iron and aluminum phosphate precipitates, rendering phosphorus unavailable for plant uptake and requiring specific management like liming to release it.

33. (B) Molybdenum
Molybdenum is an essential micronutrient whose availability is highly dependent on soil pH. Unlike other micronutrients, molybdenum becomes increasingly insoluble and bound to iron and aluminum oxides in acidic soils. This induces deficiency, which severely restricts nitrogen fixation in leguminous crops by impairing the function of nitrogenase and nitrate reductase enzymes.

34. (D) Inhibition of cell division at the root apex, causing stubby roots
Aluminum toxicity primarily targets the root system of plants grown in acid soils. Trivalent aluminum ions bind to the cell wall, plasma membrane, and DNA at the root tip. This binding inhibits cell division and elongation in the apical meristem, resulting in a stubby, poorly branched root system that restricts water and nutrient absorption.

35. (A) I, II, IV, III
The neutralizing value of liming materials is expressed relative to pure calcium carbonate, which has a reference value of one hundred percent. Burnt lime, with the lowest molecular weight, has the highest equivalent neutralizing value. This is followed by slaked lime and dolomitic limestone, while pure calcium carbonate serves as the baseline standard for these comparisons.

36. (C) 179%
The Calcium Carbonate Equivalent of a liming material is determined by its molecular weight relative to calcium carbonate. Pure burnt lime, which is calcium oxide, has a molecular weight of approximately 56 grams per mole. Because it can neutralize more acid per unit weight than calcium carbonate, its calculated chemical neutralizing value is approximately 179 percent.

37. (A) SMP buffer method
The Shoemaker-McLean-Pratt buffer method is a standard laboratory procedure used to determine the lime requirement of acid soils. This method involves mixing a soil sample with a buffered solution and measuring the resulting pH drop. The magnitude of this decrease indicates the soil's buffering capacity, allowing precise calculation of the lime needed to reach target pH.

38. (D) Calcium ions, water, and carbon dioxide
The neutralization of soil acidity by calcium carbonate is a multi-step chemical reaction. Carbonate ions react with hydrogen ions in the soil solution to form carbonic acid, which rapidly dissociates. This chemical reaction yields calcium ions, water, and carbon dioxide gas as the ultimate end products, effectively neutralizing active acidity and raising the overall pH.

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(A) The north-eastern hill states
(B) The north-western plains (e.g., Haryana and Punjab)
(C) The lateritic soils of the western ghats
(D) The dryland alfisols of the Deccan plateau

2012

174. Which specialized form of root system adaptation is classically observed in highly flood-tolerant wetland tree species like mangroves?
(A) Deep taproots
(B) Pneumatophores
(C) Contractile roots
(D) Tuberous roots

2023

175. The threshold salinity (EC_e) represents the specific soil salinity level at which:
(A) Crop yield begins to decline below its maximum potential
(B) Plant mortality occurs immediately upon exposure to salinity
(C) Seed germination is completely and permanently inhibited
(D) The soil water content becomes entirely depleted for crops

2003

176. Halophytes utilize vacuolar compartmentalization to store toxic ions. To balance the osmotic pressure in the cytoplasm, they must simultaneously synthesize:
(A) Highly toxic cellular alkaloids
(B) Extremely large starch granules
(C) Compatible organic cell solutes
(D) Insoluble calcium oxalate crystals

2024

177. The process by which acidic soils "fix" applied molybdenum, rendering it unavailable to plants, is most severe at what pH range?
(A) pH 6.5 - 7.0
(B) pH 7.5 - 8.0
(C) pH $>$ 8.5
(D) pH $<$ 5.5

2017

178. What is the effect of prolonged submergence on soil pH?
(A) Acid soils remain highly acidic and alkaline soils remain alkaline.
(B) Both acid and alkaline soils become completely sterile and inert.
(C) The pH of both soil types tends to converge toward neutrality.
(D) Soil pH drops below 4.0 due to rapid carbon dioxide accumulation.

NODIA

2025

179. A high concentration of dissolved carbonates and bicarbonates in irrigation water tends to increase the soil SAR by:
(A) Directly adding high concentrations of free sodium ions to the soil
(B) Precipitating calcium and magnesium, increasing the relative sodium
(C) Decreasing the soil pH to extremely low values via acid production
(D) Dissolving previously insoluble sodium-bearing minerals in soil

2012

180. Select the correct sequence of events occurring during the chemical reclamation of a sodic soil using gypsum:
(A) Displacement of exchangeable sodium by calcium $\rightarrow$ Leaching of sodium sulfate $\rightarrow$ Dissolution of gypsum
(B) Leaching of sodium sulfate $\rightarrow$ Dissolution of gypsum $\rightarrow$ Displacement of exchangeable sodium by calcium
(C) Dissolution of gypsum $\rightarrow$ Leaching of sodium sulfate $\rightarrow$ Displacement of exchangeable sodium by calcium
(D) Dissolution of gypsum $\rightarrow$ Displacement of exchangeable sodium by calcium $\rightarrow$ Leaching of sodium sulfate

2016

181. In the diagnosis of problematic soils, an ESP of 20 and an EC of 2.5 dS/m specifically define a:
(A) Non-saline sodic soil
(B) Saline soil
(C) Saline-sodic soil
(D) Normal agricultural soil

2003

182. A major physiological constraint of high SAR in soils is the severe deficiency of which element due to competitive exclusion by sodium?
(A) Nitrogen
(B) Phosphorus
(C) Calcium
(D) Boron

2002

183. Which engineering parameter represents the depth to which the water table must be lowered to ensure optimal crop growth in a waterlogged area?
(A) Critical water table depth
(B) Hydraulic head

greater than fifteen percent, saline-sodic soils possess an electrical conductivity greater than four decisiemens per meter. This high salt concentration keeps soil particles flocculated despite the elevated sodium content.

10. (A) Carbonate precipitation of calcium and magnesium, raising relative sodium
Sodic soil genesis in semi-arid environments is driven by the precipitation of divalent cations. As soil solution concentrates due to high evaporation, calcium and magnesium precipitate as carbonate and bicarbonate minerals. This chemical precipitation reduces the activity of divalent ions in solution, relatively increasing the concentration of monovalent sodium, which then dominates exchange sites.

11. (B) Marginal necrosis and leaf tip burn on older leaves
Chloride toxicity manifests through distinct visual symptoms on plant foliage. Because plants transport chloride ions passively through the transpiration stream, these ions accumulate preferentially at the termini of the vascular system. This high accumulation causes localized cell death, visible as characteristic marginal necrosis and leaf tip burn, starting primarily on older leaves.

12. (A) P-2, Q-3, R-4, S-1
Specific ion toxicities affect plant physiology through distinct cellular mechanisms. Sodium disrupts membrane integrity and potassium uptake, while chloride causes necrosis along the margins of older leaves. Boron toxicity leads to chlorosis and necrosis starting specifically at leaf tips, whereas toxic aluminum inhibits cell division and elongation at the root apex, resulting in stunted roots.

13. (A) Lowering soil osmotic potential, preventing water imbibition
High salinity restricts seed germination by altering the thermodynamic state of soil water. Soluble salts lower the osmotic potential of the soil solution, making it difficult for seeds to absorb moisture from their surroundings. Without adequate water imbibition, the biochemical processes and enzymatic pathways required for radicle emergence and embryo activation cannot initiate.

14. (C) Sodium
High accumulation of sodium ions in plant tissues interferes with critical physiological and biochemical functions. Under saline conditions, excessive intracellular sodium disrupts the potassium-dependent enzyme systems, damages chloroplast structures, and accelerates chlorophyll degradation. This ionic stress directly reduces photosynthetic efficiency, leading to stunted vegetative growth and lower overall crop yields.

15. (A) I, II and IV
Reclamation of sodic soils requires replacing exchangeable sodium with calcium. Gypsum directly supplies soluble calcium ions, while iron pyrites must undergo microbial oxidation under aerobic conditions to produce sulfuric acid, which dissolves native calcium carbonate. Additionally, organic manures release organic acids during decomposition, lowering the high soil pH and improving structural stability.

16. (B) 86 g/eq
The chemical equivalent weight of agricultural grade gypsum is crucial for calculating the amendment quantity needed for sodic soil reclamation. Since gypsum is a divalent salt with a molecular formula of calcium sulfate dihydrate, its molecular weight is approximately 172 grams per mole. Dividing this molecular weight by its valence yields an equivalent weight of eighty-six.

17. (B) Surface application under moist, well-aerated soil conditions
Iron pyrites require specific environmental conditions to act as an effective reclaiming agent. The chemical transformation of pyrite into sulfuric acid is a biological oxidation process mediated by autotrophic bacteria like Thiobacillus. This process requires a continuous supply of oxygen and moisture, making surface application under well-aerated conditions essential for maximum efficiency.

18. (D) It dissolves native calcium carbonate to release soluble calcium.
Sulfuric acid is a highly effective chemical amendment when applied to calcareous sodic soils. It does not replace sodium directly but reacts instantly with insoluble native calcium carbonate present in the soil. This chemical reaction dissolves the carbonate minerals, releasing soluble calcium ions into the soil

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2022

194. In crop selection for problem soils, barley is generally preferred over wheat in highly saline areas because barley:
(A) Requires significantly higher water quantities than standard wheat
(B) Has a shallower and more compact root system under stress
(C) Has a higher salt threshold level and lower rate of yield decline
(D) Can fix its own atmospheric nitrogen through symbiosis

2009

195. Arrange the following soil textural classes in order of increasing required drainage coefficient (i.e., from easiest to drain to most difficult to drain requiring intensive systems):
I. Heavy Clay
II. Loamy Sand
III. Silt Loam
Which of the above sequences is correct?
(A) II, III, I
(B) I, III, II
(C) II, I, III
(D) III, II, I

2011

196. Which index provides a comprehensive evaluation of irrigation water quality by incorporating the effects of EC, SAR, and the varying sensitivity of different crops?
(A) Crop Tolerance Index
(B) Universal Soil Loss Equation
(C) Aridity Index
(D) USSL Classification System

2018

197. The concept of "relative yield" is frequently utilized in salinity research to:
(A) Compare stress yield to maximum yield under non-saline conditions
(B) Compare the dry weight of root systems to shoot systems directly
(C) Determine the exact financial profit margin per hectare of land
(D) Measure the total biomass of weeds relative to the main crop yield

2019

198. Excessive groundwater extraction in coastal agricultural regions is highly problematic because it directly induces:
(A) Extreme soil acidity
(B) The rapid formation of deep gullies
(C) Seawater intrusion into freshwater coastal aquifers
(D) The spontaneous creation of artesian wells

2011

199. When assessing shallow groundwater contribution to crop evapotranspiration, the contribution generally increases as:
(A) Capillary rise capacity of the soil profile increases
(B) Overall depth of the groundwater table increases
(C) Effective depth of the crop root system decreases
(D) Atmospheric evaporative demand drops completely to zero

2015

200. In evaluating the economic feasibility of reclaiming a sodic soil, which factor usually constitutes the highest initial capital cost?
(A) Purchasing high-yielding crop seeds and planting materials
(B) Hiring agricultural labor for hand weeding and maintenance
(C) Purchasing specialized foliar micronutrient spray mixtures
(D) Procurement, transport, and application of chemical amendments

2011

201. Which specific practice is most effective in managing the severe weed competition that often occurs in pre-flood and post-flood crop planning?
(A) Broadcasting crop seeds loosely on the untreated soil surface
(B) Adopting stale seedbed techniques and early post-emergence control
(C) Refraining from plowing and tillage operations altogether
(D) Applying heavy doses of nitrogenous fertilizers at early stages

2010

202. The "salt balance" of an irrigated agricultural watershed is considered favorable or sustainable when:
(A) Zero soluble salts are permitted to leave the crop root zone under any conditions
(B) The total mass of salts applied is ten times higher than the total mass removed
(C) Salt imported via irrigation equals or is less than salt exported via drainage
(D) Total regional evaporation precisely equals total annual precipitation values

NODIA

(C) Drainage coefficient
(D) Specific yield

2008

184. In estimating the limestone requirement for an acid soil, the concept of "buffer capacity" primarily relates to the soil's content of:
(A) Sand and gravel
(B) Soluble nitrates
(C) Iron oxides
(D) Clay and organic matter

2005

185. A key principle of managing irrigation with brackish water is the "conjunctive use" of multi-quality waters. Which of the following best exemplifies "blending"?
(A) Applying fresh water in wet seasons and brackish water in dry seasons
(B) Mixing fresh and saline waters to achieve a safe salinity level
(C) Irrigating alternate crop rows with different quality water sources
(D) Applying fresh water on the surface and injecting saline water below

2011

186. Which physiological trait is commonly utilized by salt-excluder plants to prevent salt accumulation in shoot tissues?
(A) Maintaining extremely high crop transpiration rates
(B) Rapid and continuous shedding of newly formed leaves
(C) Retention of sodium in roots and lower stem tissues
(D) Secretion of toxic salt through specialized root hairs

2022

187. The specific phenomenon whereby prolonged heavy rainfall leaches basic cations and leaves acidic cations dominating the soil exchange complex results in the formation of:
(A) Caliche hardpans
(B) Saline seeps
(C) Vertic slickensides
(D) Humid region acid soils

2015

188. In waterlogged ecosystems, the term "Eh" specifically refers to:
(A) The redox (oxidation-reduction) potential
(B) The electrical conductivity of the water
(C) The exchangeable hydrogen ion concentration
(D) The rate of evapotranspiration

2001

189. A primary ecological concern with large-scale inland saline aquaculture in degraded agricultural lands is:
(A) The attraction of large herbivorous mammals to the pond areas
(B) Saline seepage impacting adjacent fertile lands and aquifers
(C) The rapid and uncontrolled decrease in local atmospheric humidity
(D) The spontaneous combustion risk of dried pond sediment layers

2009

190. Which of the following is a classic visual symptom of specific boron toxicity in many crop plants?
(A) Interveinal chlorosis of the youngest leaves
(B) Necrosis at margins and tips of older leaves
(C) Dark purple discoloration of the lower stems
(D) Wilting of the plant despite adequate moisture

2004

191. During the chemical neutralization reaction between calcium carbonate and soil active acidity, what gas is notably evolved?
(A) Carbon dioxide
(B) Methane
(C) Hydrogen sulfide
(D) Ammonia

2010

192. Which soil test extractant is most commonly recommended for determining available phosphorus in acid soils?
(A) Olsen's extractant (Sodium bicarbonate)
(B) Neutral normal ammonium acetate
(C) Bray's No. 1 extractant (Dilute acid-fluoride)
(D) DTPA extractant

2021

193. The reclamation of acid sulfate soils requires a combination of water table management and liming. To prevent the massive production of sulfuric acid, the water table should be managed to:
(A) Keep the pyrite-rich layers continuously saturated
(B) Lower the water table as deep as possible to promote rapid aeration
(C) Fluctuate the water table rapidly to wash out the acidity
(D) Maintain the soil in a completely dry state throughout the year

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ANSWERS

1. (B) Soils with severe surface crusting and subsurface hardpans
Physical constraints in problematic soils are characterized by structural degradation rather than chemical imbalances. Severe surface crusting impedes seedling emergence, while dense subsurface hardpans restrict root penetration and vertical water movement. These physical barriers limit overall crop productivity by reducing aeration and water infiltration, necessitating mechanical interventions like deep tillage.

2. (D) Extreme soil acidity
Extreme soil acidity significantly lowers the soil pH, which directly influences chemical solubility and availability. At low pH levels, aluminum-bearing minerals dissolve, releasing phytotoxic trivalent aluminum ions that damage roots. This acidic environment simultaneously accelerates the leaching of exchangeable bases like calcium, leading to severe nutritional deficiencies and restricted plant development.

3. (C) I and III
Soil biology is highly sensitive to abiotic stressors like salinity and waterlogging. Excessive soluble salts increase osmotic pressure and toxic ion concentrations, which reduces microbial biomass and enzymatic processes. Similarly, prolonged inundation depletes oxygen, forcing soil microorganisms to transition from aerobic respiration to less efficient anaerobic pathways, altering nutrient cycling dynamics.

4. (B) 6.7 million hectares
India possesses a vast area of salt-affected soils, which are categorized into saline and sodic soils. According to official estimates, this total area occupies approximately 6.7 million hectares distributed across several states. Managing these lands requires systematic reclamation strategies, including chemical amendments and drainage, to restore their agricultural productivity and food security.

5. (A) Gujarat
Gujarat possesses the largest area under salt-affected soils in India, particularly coastal saline tracts. The extensive coastline, low-lying topography, and high evaporative demand facilitate marine inundation and salt accumulation. This geographic vulnerability is compounded by saline groundwater, necessitating specialized management practices like brackish water aquaculture and salt-tolerant cropping systems to utilize these lands.

6. (D) Western Ghats, North-Eastern states, and Himalayan regions
Acid soils in India are predominantly located in regions characterized by high rainfall and humid climates. The Western Ghats, North-Eastern states, and parts of the Himalayan territory experience intense precipitation that leaches basic cations like calcium from the soil profile. This process leaves behind acidic iron and aluminum oxides, lowering the soil pH.

7. (B) $EC > 4$ dS/m, $ESP < 15$, $pH < 8.5$
The United States Salinity Laboratory classifies saline soils based on specific chemical parameters. These soils contain high concentrations of neutral soluble salts, resulting in an electrical conductivity greater than four decisiemens per meter. However, the exchangeable sodium percentage remains below fifteen percent, and the soil reaction is typically near-neutral, with pH values below 8.5.

8. (A) Both A and R are true and R is the correct explanation of A.
Sodic soils suffer from severe physical degradation directly caused by chemical imbalances. The dominance of exchangeable sodium ions on soil colloids increases the hydration thickness, causing clay particles to disperse. This dispersion destroys soil aggregates, blocks pore spaces, and creates a dense, impermeable structure with exceptionally low water infiltration rates and poor aeration.

9. (D) An electrical conductivity greater than 4 dS/m
Saline-sodic soils are differentiated from purely sodic soils by their high concentration of neutral soluble salts. While both soil types exhibit high exchangeable sodium percentages

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(B) Smectite clay
(C) Primary silicate minerals
(D) Iron and aluminum oxides

2019

165. The primary disadvantage of using raw iron pyrites for sodic soil reclamation compared to gypsum is that pyrites:
(A) Require aerobic, moist conditions for microbial oxidation
(B) Contain highly toxic levels of industrial heavy metals
(C) Possess high water solubility and leach away instantly
(D) Drastically elevate soil exchangeable sodium percentage

2003

166. A critical factor determining the success of deepwater rice in flood plains is its capacity for rapid internodal elongation, which is hormonally regulated primarily by:
(A) Abscisic acid
(B) Cytokinin
(C) Ethylene and Gibberellin
(D) Salicylic acid

2007

167. Which term describes the gradual accumulation of salts in the root zone resulting directly from the repeated application of irrigation water containing dissolved salts?
(A) Secondary salinization
(B) Primary salinization
(C) Alkalization
(D) Solodization

2005

168. The "safe yield" or "sustainable yield" of a groundwater basin is theoretically defined as the amount of water that can be extracted:
(A) In a single year to completely empty the aquifer system
(B) Using highly specialized solar-powered pumping systems
(C) Before the groundwater becomes completely saline and unusable
(D) Without exceeding long-term average recharge to avoid depletion

2003

169. What is the main agronomic purpose of applying a "heavy pre-sowing irrigation" (rauni) with good quality water in saline soils?
(A) To raise the shallow groundwater table to the soil surface
(B) To leach surface salts below the seed germination zone
(C) To compact the soil seedbed before planting operations
(D) To eliminate harmful pathogenic soil microorganisms

2002

170. Match the problem soil type (List I) with its most appropriate and standard chemical amendment (List II).
List I: (Problem soil type)
P. Sodic soil
Q. Acid soil
R. Acid sulfate soil
S. Saline soil (without high sodium)
List II: (Chemical amendment)
1. No chemical amendment required; needs leaching and drainage
2. Agricultural limestone ($CaCO_3$)
3. Heavy liming and controlled water table management
4. Gypsum ($CaSO_4 \cdot 2H_2O$)
(A) P-2, Q-4, R-1, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

2003

171. The application of organic mulches on the surface of saline soils helps to mitigate salinity buildup primarily by:
(A) Chemically neutralizing sodium ions on soil exchange complex
(B) Increasing the reflection of sunlight to cool the soil surface
(C) Directly absorbing soluble salts into the organic mulch tissue
(D) Reducing surface evaporation to minimize upward salt movement

NODIA

2021

172. When analyzing irrigation water, the term "Specific Ion Toxicity" evaluates the hazards posed mainly by which trio of elements?
(A) Sodium, Chloride, Boron
(B) Nitrogen, Phosphorus, Potassium
(C) Calcium, Magnesium, Sulfur
(D) Iron, Manganese, Zinc

2004

173. Inland saline aquaculture has proven particularly economically viable in which region of India affected by secondary salinization and waterlogging?

solution to replace exchangeable sodium on the clay complex.

19. (A) Ion exclusion
Plants employ diverse physiological mechanisms to cope with salinity stress in their environment. Ion exclusion is a vital strategy whereby the root system restricts the upscale or transport of toxic sodium and chloride ions. This prevents these harmful ions from accumulating in the sensitive shoots and photosynthetic tissues, protecting critical metabolic processes from disruption.

20. (A) Selective ion uptake → Root endodermis exclusion → Vacuolar compartmentalization
Halophytes survive in highly saline environments through a hierarchical series of physiological mechanisms. Initially, selective ion uptake at the root surface restricts harmful ions. Next, the root endodermis acts as a physical barrier to exclude sodium from the xylem. Finally, ions that enter cells are actively compartmentalized into vacuoles, preventing cytosolic toxicity.

21. (A) Proline
Under salt stress, plants accumulate specific low-molecular-weight organic compounds known as compatible solutes. Proline is a widely studied osmoprotectant that accumulates in the cytosol to facilitate osmotic adjustment. It helps maintain cell turgor, stabilizes protein structures, and scavenges reactive oxygen species, thereby protecting cellular machinery from the damaging effects of dehydration and salinity.

22. (D) Na+/H+ antiporters
Vacuolar compartmentalization of sodium is a key mechanism of salinity tolerance in plants. This active transport process is mediated by sodium-proton antiporters located on the tonoplast membrane. Powered by the proton gradient generated by pyrophosphatases and ATPases, these antiporters pump toxic sodium ions into the vacuole, maintaining a low and safe cytosolic sodium concentration.

23. (B) Barley
Barley is recognized globally as one of the most salt-tolerant field crops. It maintains cellular function and growth under high salinity levels through efficient potassium-sodium selection and osmotic adjustment. In contrast, sensitive crops like beans and onions suffer severe physiological damage and yield decline even at low levels of soluble salts in the root zone.

24. (C) CSR 10
CSR 10 is a highly recognized alkali-tolerant rice variety developed by the Central Soil Salinity Research Institute in India. Specifically bred for sodic environments, it can tolerate high pH and exchangeable sodium percentages. This variety allows farmers to obtain productive grain yields from degraded soils, facilitating the biological reclamation process in alkali tracts.

25. (A) I, II, III and V
Selecting crop varieties for salt tolerance involves assessing key physiological traits. Desirable characteristics include maintaining a high potassium-sodium ratio, showing early seedling vigor to establish crops quickly, and possessing deep root systems. Additionally, high synthesis rates of compatible osmolytes prevent cellular dehydration, whereas high stomatal conductance under severe stress can cause excessive water loss.

26. (A) Date palm
Date palm is a highly resilient fruit crop suitable for cultivation on degraded lands in arid and semi-arid zones. It exhibits remarkable tolerance to high soil salinity and can withstand harsh climatic conditions. This resilience is attributed to its robust root system and efficient osmotic regulation, making it ideal for agroforestry in problematic soils.

27. (B) Soil solution
Soil acidity is categorized into different pools based on the location of hydrogen ions. Active soil acidity is defined as the concentration or activity of hydrogen ions present in the soil solution. This pool represents a very small fraction of total acidity, but it directly influences root development and nutrient availability in the rhizosphere.

28. (B) Reserve or residual acidity
Reserve or residual acidity comprises hydrogen and aluminum ions that are tightly bound to organic matter and non-exchangeable mineral surfaces. This pool constitutes the largest fraction of total soil acidity. To permanently raise soil pH, liming materials must neutralize both the active acidity and this substantial reserve capacity through continuous buffering reactions.

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2003

203. Which heavy metal is frequently observed in toxic concentrations in highly acidic soils derived from mine spoils?
(A) Lead
(B) Cadmium
(C) Mercury
(D) Manganese

2008

204. In the design of subsurface drainage, if the horizontal saturated hydraulic conductivity of the soil is very low (e.g., in heavy clays), the required spacing between lateral drains must be:
(A) Narrow and closely spaced
(B) Excessively wide
(C) Exactly equal to the drain depth
(D) Replaced entirely by surface drains

2016

205. The primary biological constraint restricting plant growth in severely crusted problematic soils is:
(A) Excessive attack by airborne pathogenic fungal spores
(B) Physical impedance of seedling emergence and root growth
(C) Rapid and uncontrolled multiplication of native earthworms
(D) Over-accumulation of symbiotic nitrogen-fixing bacteria

2007

206. Which method is most effective for preventing the secondary salinization of productive agricultural lands?
(A) Continuous flood irrigation of fields using fresh canal water
(B) Adequate subsurface drainage with rational irrigation scheduling
(C) Complete and permanent cessation of all local farming activities
(D) Heavy and frequent application of chemical synthetic fertilizers

2012

207. A critical mechanism by which halophytic plants manage high intracellular sodium is the compartmentalization of Na^+ into the vacuole. This process is driven energetically by:
(A) A proton gradient generated by vacuolar H+-ATPases
(B) Direct utilization of incoming solar radiation
(C) Passive diffusion of water through aquaporins
(D) Rapid degradation of photosynthetic chlorophyll

2010

208. When estimating the gypsum requirement for a sodic soil in the laboratory, the method fundamentally measures the amount of calcium needed to replace:
(A) The total pool of exchangeable potassium
(B) Soluble chloride ions in the soil solution
(C) Exchangeable sodium down to a safe percentage
(D) Exchangeable aluminum and hydrogen fractions

2007

209. Inland saline water shrimp farming frequently faces the challenge of "mineral stress" in cultured organisms. This is best ameliorated by:
(A) Increasing water salinity with commercial table salt (sodium chloride)
(B) Draining and refilling the pond entirely every week
(C) Shading the ponds to prevent any surface evaporation
(D) Supplying commercial mineral mixtures rich in potassium and magnesium

NODIA

2002

210. The fundamental long-term goal of integrating alternate land-use systems on problematic soils is to:
(A) Convert lands quickly back into intensive, high-input monocultures
(B) Completely sterilize the soil profile to prevent any weed growth
(C) Achieve restoration, carbon sequestration, and sustainable returns
(D) Exhaust the remaining shallow groundwater reserves in the region

****

39. (B) Gradual decline from positive to negative values
Soil submergence halts gaseous exchange with the atmosphere, rapidly depleting dissolved oxygen. As anaerobic microorganisms utilize alternative electron acceptors for respiration, the redox potential of the waterlogged soil undergoes a sequential decline. This transition moves the soil environment from an oxidized state to a highly reduced state, characterized by negative millivolt values.

40. (B) II only
In waterlogged soils, anaerobic conditions alter the oxidation states of several elements. Nitrate is rapidly reduced to gaseous nitrogen forms, while ferric iron is reduced to more soluble ferrous iron. However, manganic manganese is reduced, not oxidized, to more soluble manganous forms, meaning that only the second statement regarding manganese oxidation is incorrect.

41. (D) Extreme reduction and strict anaerobiosis ($Eh < -150$ mV)
Methane production in submerged soils is a highly anaerobic biological process. Methanogenic archaea are strict anaerobes that become active only under extremely reducing conditions, typically when the soil redox potential drops below negative one hundred and fifty millivolts. At this stage, alternative electron acceptors like oxygen, nitrate, and sulfate have been completely depleted.

42. (A) Iron
Prolonged waterlogging creates highly reducing conditions that transform insoluble ferric iron into highly soluble ferrous iron. In wetland environments, this rapid reduction can increase ferrous iron concentrations to toxic levels. This excess iron is absorbed by crops like rice, leading to physiological disorders such as iron bronzing and reduced vegetative growth.

43. (B) Groundwater depth restricting aeration and reducing crop yield
The critical water table depth is an agricultural boundary layer that directly influences plant health. It represents the depth at which the groundwater table rises close enough to the soil surface to restrict root zone aeration. This prolonged saturation causes oxygen depletion, which severely impairs crop root respiration and significantly reduces overall agricultural yields.

44. (B) Depleted oxygen levels causing root suffocation
A shallow water table restricts the root growth of mesophytic crops by filling soil macropores with water. This saturation prevents the rapid diffusion of atmospheric oxygen into the root zone. Under these hypoxic conditions, roots suffer from oxygen starvation and suffocate, which halts root elongation, disrupts nutrient absorption, and reduces overall crop vigor.

45. (A) P-2, Q-3, R-4, S-1
Soil redox potential determines the sequential reduction of alternative electron acceptors by anaerobic microbes. Nitrate and manganese are reduced first at positive potentials. Iron reduction occurs as the potential drops further, followed by sulfate reduction under more reduced conditions. Finally, carbon dioxide serves as the electron acceptor during methanogenesis under extreme reduction below negative two hundred millivolts.

46. (C) Arid and semi-arid climates with high evaporative demand
Capillary rise from shallow, saline groundwater tables exacerbates root zone salinity under specific climatic influences. Arid and semi-arid regions experience extremely high evaporative demand alongside low precipitation. This imbalance drives the upward movement of saline water through the soil capillary network, depositing dissolved salts on the soil surface as the water evaporates.

47. (D) Darcy's Law for upward unsaturated flow
Estimating the contribution of shallow groundwater to crop water use requires understanding soil physics. Darcy's Law, adapted for unsaturated soil conditions, describes water movement in response to hydraulic gradients. This mathematical formulation calculates the upward capillary flux of water from a water table toward the root zone, driven by transpirational pull and soil matrix potential.

48. (C) Silt loam
Upward capillary flux is heavily influenced by soil texture. While coarse sandy soils have large pores that limit capillary rise, heavy clay soils have very fine pores that create high resistance to water movement. Silt loam soils possess an optimal pore size distribution that maximizes

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both capillary rise height and the overall rate of upward water flux.

49. (B) Crop evapotranspiration and deep percolation
Lysimeters are specialized scientific instruments utilized in agricultural and hydrological research. They consist of isolated blocks of soil, with or without vegetation, equipped to monitor the water balance. These devices provide highly precise measurements of crop water consumption via evapotranspiration, as well as the volume of water moving downward as deep percolation.

50. (A) Both A and R are true and R is the correct explanation of A.
Aquifer depletion is a critical environmental challenge in intensive agricultural regions. This hydrological imbalance occurs when the rate of groundwater extraction for irrigation exceeds the natural recharge rate of the aquifer. Over time, this unsustainable extraction lowers the water table, increases pumping costs, and can lead to land subsidence or saltwater intrusion.

51. (A) Localized waterlogging and salinization
Unlined irrigation canals often lose significant volumes of water through lateral and vertical seepage. This continuous seepage raises the local groundwater table toward the soil surface, causing waterlogging in adjacent agricultural fields. In arid and semi-arid regions, this shallow water table subsequently leads to salinization via capillary rise and surface evaporation.

52. (C) Replenish groundwater resources using excess surface water
Managed Aquifer Recharge is an engineering and hydrological management technique used to restore depleted aquifers. This process involves the intentional diversion and infiltration of excess surface water, such as storm runoff or treated wastewater, into the ground. This practice replenishes declining groundwater levels, improves water security, and helps mitigate saltwater intrusion.

53. (A) Percolation tanks
Percolation tanks are artificially constructed surface water bodies designed to capture rainwater runoff in semi-arid watersheds. By holding water over a highly permeable soil surface, these structures facilitate gravity-driven infiltration into the underlying geological formations. This localized recharge helps replenish shallow unconfined aquifers, sustaining agricultural tube wells during dry seasons.

54. (D) Electrical Conductivity (EC))
The salinity hazard of irrigation water is standardly expressed by measuring its electrical conductivity. Dissolved salts conduct electricity, and their concentration in water is directly proportional to the measured electrical conductivity. This parameter indicates the osmotic stress that crops will experience, allowing farmers to predict potential yield declines and plan leaching requirements.

55. (B) Calcium and Magnesium
The Sodium Adsorption Ratio is a critical index used to evaluate the sodicity hazard of irrigation water. It quantifies the relative concentration of monovalent sodium ions in relation to the divalent calcium and magnesium ions. This ratio predicts the likelihood of sodium replacing calcium and magnesium on the soil exchange complex, which causes structure dispersion.

56. (C) $\left(CO_3^{\{2-\}} + HCO_3^-\right) - \left(Ca^{\{2+\}} + Mg^{\{2+\}}\right)$
Residual Sodium Carbonate is a key chemical parameter used to assess the alkalinity hazard of irrigation water. It is calculated by subtracting the combined concentrations of calcium and magnesium ions from the sum of carbonate and bicarbonate ions. This calculation indicates whether calcium and magnesium will precipitate as carbonates, raising exchangeable sodium.

57. (D) Unsuitable for irrigation due to severe alkali hazard
Irrigation water with a Residual Sodium Carbonate value greater than 2.5 milliequivalents per liter is classified as highly hazardous. High bicarbonate levels cause calcium and magnesium to precipitate as carbonates in the soil. This chemical process increases the relative concentration of sodium, causing aggregate dispersion, soil structure degradation, and restricted water movement.

58. (A) High salinity and low sodium hazard
In the United States Salinity Laboratory classification system, alphanumeric codes represent specific water quality characteristics. The designation C_3 indicates high salinity water, which can create osmotic stress for sensitive crops. The designation S1 indicates low sodium

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hazard, meaning there is minimal risk of sodium accumulating on exchange sites and dispersing soil structure.

59. (B) Using fresh water for sensitive and brackish for tolerant growth stages
Cyclic or alternating use is a management strategy for brackish water irrigation. This practice involves using high-quality fresh water during sensitive crop growth stages, such as seed germination and seedling establishment. Once the crop reaches a more tolerant vegetative or reproductive stage, brackish water is utilized, thereby optimizing overall water resources.

60. (A) I, II and IV
Managing brackish water requires specific agronomic practices to minimize salt stress. Micro-irrigation systems apply water efficiently, maintaining high matrix potential and keeping salts dilute near roots. Pre-sowing irrigation with fresh water establishes seedlings successfully. Conversely, organic manures improve soil physical properties and buffer salinity, making statements excluding organic manure benefits correct.

61. (A) Maintain soil salinity at a tolerable level for crops
The Leaching Requirement represents the fraction of applied irrigation water that must pass through the root zone to control soil salinity. This extra water dissolves accumulated soluble salts and carries them below the active root zone, preventing salinization. This practice maintains the electrical conductivity of the root zone within tolerable crop limits.

62. (C) $LR = \frac{EC_w}{5 \times EC_e - EC_w}$
The Leaching Requirement is calculated using a standard mathematical formula that relates the electrical conductivity of irrigation water to the crop-specific salt tolerance. In this formulation, the salt tolerance is represented by the electrical conductivity of the soil saturation extract at a specified acceptable yield reduction, ensuring effective salinity management.

63. (D) Submergence tolerance and elongation
Contingent crop planning in flood-prone environments relies on varieties that can survive sudden, prolonged inundation. These crops must possess genetic traits for submergence tolerance, such as the ability to conserve energy underwater. Alternatively, deepwater varieties utilize rapid internode elongation to keep their photosynthetic canopy above the rising floodwaters, sustaining vital gas exchange.

64. (C) Minimum tillage planting of short-duration crops
Following the recession of floodwaters, fields often remain highly saturated and prone to compaction. Direct, minimum tillage planting of short-duration crops takes immediate advantage of residual soil moisture without causing structural damage through heavy machinery. This strategy allows farmers to secure a harvest within the remaining seasonal window.

65. (B) Elongate internodes rapidly to keep foliage above rising water
Deepwater rice is uniquely adapted to survive extreme flooding through a specialized morphological response. As water levels rise, the plant senses physical cues that trigger rapid internode elongation. This rapid growth ensures that the leaves and panicles remain above the water surface, maintaining essential photosynthetic activity and oxygen transport to the roots.

66. (D) It is grown in winter/spring using residual moisture after floods recede
Boro rice is a traditional cropping system practiced in low-lying, flood-prone regions. Instead of cultivation during the high-risk monsoon, boro rice is transplanted during the winter season as floodwaters recede. The crop relies on abundant residual soil moisture and supplemental irrigation, escaping the destructive peak flood period while utilizing fertile alluvial deposits.

67. (A) Escape the historically most probable period of inundation
Adaptive crop calendars are designed to mitigate flood risks in vulnerable agricultural landscapes. By analyzing historical weather and hydrological data, planting dates are shifted to ensure that sensitive growth stages do not coincide with peak flood periods. This temporal escape strategy minimizes crop exposure to inundation, safeguarding seasonal yields.

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detect only the free, thermodynamically active form of the ion. This distinction is critical for understanding plant nutrient availability and chemical equilibrium in complex soil systems.

129. (D) Intracellular solute accumulation to maintain cell turgor
Osmotic adjustment is a vital physiological mechanism employed by plants under salinity or drought stress. It involves the active intracellular accumulation of inorganic ions and compatible organic solutes, such as proline and sugars. This process lowers the cellular osmotic potential, allowing the plant to absorb water from dry or saline soils and maintain turgor.

130. (C) Ammonium sulfate
Ammonium sulfate is highly acid-forming because both the nitrification of ammonium and the plant uptake of nitrogen release hydrogen ions into the soil. In soils that are already highly acidic, applying this fertilizer further reduces soil pH. This rapid acidification exacerbates aluminum and manganese toxicities while decreasing the availability of essential nutrients.

131. (B) Soil hydraulic conductivity characteristics
The upward capillary flux of water from a shallow water table to the crop root zone is a critical hydrological process. This upward movement depends primarily on the depth of the water table and the soil hydraulic conductivity characteristics. Finer soils with balanced pore structures sustain greater upward capillary flow compared to coarse sands.

132. (D) Calcium phosphates
In alkaline, calcareous soils, the high concentration of soluble calcium ions and active calcium carbonate dominates chemical reactions. Soluble phosphorus reacts rapidly with this calcium to form a sequence of increasingly insoluble calcium phosphate minerals. This chemical precipitation process restricts the availability of phosphorus, making it difficult for crops to absorb.

133. (A) Concentrations exceeding 1-2 mg/L (ppm))
Boron is an essential micronutrient, but the margin between deficiency and toxicity is exceptionally narrow. When irrigation water contains boron concentrations exceeding one to two milligrams per liter, it poses a severe toxicity risk to sensitive crops. Boron accumulates in leaf tips, causing marginal necrosis and significant yield loss in agricultural systems.

134. (C) Utilizing groundwater or surface water in dry winter
Boro rice is cultivated during the dry winter-spring season, starting with transplanting in December or January and harvesting by April or May. Since this crop grows during the dry period of the year, it relies entirely on irrigation. Farmers utilize groundwater resources or residual surface water to satisfy the high crop water requirements.

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135. (A) Improved root zone aeration above the saturated layer
The furrow-irrigated raised bed planting system is highly effective in fields with shallow water tables. Planting crops on elevated beds keeps the primary root zone raised above the saturated soil layer. This physical separation prevents waterlogging in the root zone, ensures adequate soil aeration, and protects crops from oxygen deficiency and root rot.

136. (D) Exhibits significant deficiencies in potassium and calcium
Inland saline groundwater used for aquaculture has a vastly different ionic profile compared to ocean water diluted to the same salinity. It typically lacks proportional concentrations of essential ions, exhibiting severe deficiencies in potassium, calcium, and magnesium. These ionic imbalances must be corrected through chemical amendments to ensure the survival of marine organisms.

137. (B) Chlorides and sulfates of sodium, calcium, and magnesium
White alkali soils, commonly known as saline soils, are characterized by high concentrations of neutral soluble salts. These salts are primarily the chlorides and sulfates of sodium, calcium, and magnesium. Upon evaporation of soil water, these salts precipitate on the soil surface to form a distinctive, white, crystalline crust that does not disperse organic matter.

138. (C) Nitrous oxide (N_2O) and dinitrogen (N_2) gases
Denitrification is a biological process that occurs in waterlogged, anaerobic soils where oxygen is absent. Facultative anaerobic bacteria use nitrate as an alternative electron acceptor to

78. (C) Salt-tolerant fish and shrimp
Inland saline water aquaculture is a productive land-use alternative for severely degraded agricultural areas. This practice involves constructing ponds in areas with saline groundwater to cultivate salt-tolerant aquatic organisms like fish and shrimp. This approach turns unproductive, waterlogged, and saline lands into economically viable aquaculture zones, supporting farming communities.

79. (D) Tolerating wide salinity fluctuations
The Pacific white shrimp is highly favored for inland saline aquaculture due to its remarkable osmoregulatory capacity. It can tolerate wide fluctuations in water salinity, ranging from near-freshwater to hyper-saline conditions. This physiological flexibility allows successful cultivation in diverse and fluctuating groundwater salinity environments typical of degraded agricultural lands.

80. (C) V only
Inland saline shrimp farming faces unique challenges, including ionic imbalances like low potassium, toxic nitrogenous accumulation, and high seepage in sandy soils. However, these systems do not have an absolute dependence on fresh water for daily flushing, as the shrimp are adapted to saline conditions. Thus, only the fifth statement is incorrect.

81. (B) Sufficient clay to retain water and minimize seepage
Constructing aquaculture ponds in degraded soils requires specific physical soil properties to ensure water retention. The soil profile must contain a sufficient percentage of clay to create an impermeable barrier. This low hydraulic conductivity minimizes water loss through seepage, ensuring that saline water levels remain stable within the ponds.

82. (D) Flocculating clay particles and enhancing soil structure
Gypsum improves the hydraulic properties of sodic soils by modifying soil chemistry. Soluble calcium from gypsum replaces exchangeable sodium on clay particles, which reduces the electrical double layer. This process promotes the flocculation of dispersed clay, leading to the formation of stable soil aggregates and significantly increasing hydraulic conductivity.

83. (A) Potassium
Sodium toxicity in plants is closely linked to nutritional competition. Because sodium and potassium ions share similar chemical properties, high external sodium levels competitively inhibit potassium uptake through root transporters. This disrupts cellular potassium-sodium ratios, impairing essential enzyme activation, protein synthesis, and stomatal regulation within the plant.

NODIA

84. (C) EC of the soil saturation extract (ECe)
The electrical conductivity of the soil saturation extract is the standard scientific indicator of root zone salinity. Unlike irrigation water conductivity, which does not account for soil accumulation, the saturation extract reflects the actual concentration of soluble salts surrounding plant roots, providing a reliable measure of osmotic stress.

85. (A) Iron, Zinc, and Phosphorus
Calcareous soils contain significant amounts of calcium carbonate, which buffers the soil pH in the alkaline range. This high pH and abundance of calcium ions lead to the chemical precipitation of phosphorus as calcium phosphates. Simultaneously, it drastically reduces the solubility of essential micronutrients like iron and zinc, inducing severe nutritional deficiencies.

86. (D) Continuous application of heavy flood irrigation
Managing active waterlogging in heavy clay soils requires improving drainage and soil aeration. Feasible strategies include installing subsurface tile drains, constructing raised beds, and planting high-transpiration trees. Conversely, continuous heavy flood irrigation is highly inappropriate, as it exacerbates waterlogging, depletes soil oxygen, and worsens anaerobic structural decline.

87. (B) Nitrogen (as ammonia gas))
Under high pH conditions typical of alkaline and sodic soils, the chemical equilibrium of ammonium nitrogen is shifted. Soluble ammonium ions are rapidly converted into volatile ammonia gas. This process significantly accelerates volatilization losses of applied urea or ammonium fertilizers, reducing nitrogen use efficiency and requiring specific placement techniques.

this zone, water is drawn upward from the water table by capillary action, filling the soil pores to near-saturation. Although the soil pores are saturated with water, the water is held under tension or negative pressure relative to the atmosphere.

109. (B) Potassium
Inland saline groundwater used for shrimp aquaculture frequently lacks the balanced ionic composition of natural seawater. This water is particularly deficient in potassium and magnesium, which are essential for the physiological functions and osmoregulation of whiteleg shrimp. Supplementing potassium is necessary to ensure survival, proper growth, and regular molting cycles in these inland systems.

110. (B) P-2, Q-3, R-4, S-1
Crop species display varying levels of tolerance to soil salinity. Sugarbeet is highly tolerant, making it resilient in saline environments. Cotton is classified as tolerant, whereas wheat is moderately tolerant to moderate salt levels. Conversely, sensitive crops like beans are highly susceptible to yield loss and physiological damage under even low salinity conditions.

111. (A) Electromagnetic induction
Electromagnetic induction is a rapid and non-destructive technique used for field mapping of bulk soil electrical conductivity. The instrument induces an electromagnetic field in the ground, measuring the secondary magnetic field produced by the soil. This measurement correlates directly to soil salinity, water content, and clay content without requiring soil core extraction.

112. (C) < 5.0
Soil pH strongly governs the solubility of metallic elements. When soil pH drops below five, the solubility of iron and aluminum oxides increases dramatically. This geochemical change releases toxic concentrations of aluminum and iron ions into the soil solution, which severely restricts root elongation, compromises cell membrane integrity, and damages agricultural crops.

113. (D) Low dissolved oxygen in floodwater
Floodwater acts as a physical barrier that severely restricts the diffusion of atmospheric gases. Oxygen dissolves very slowly in water, resulting in rapid depletion of dissolved oxygen in chronically flooded ecosystems due to respiration by roots and microbes. This severe hypoxic environment blocks aerobic respiration in plants, posing the main challenge to survival.

114. (C) Prevent fine soil particles from clogging the drain
Subsurface tile drainage pipes require a protective envelope to function efficiently over long periods. Installing a gravel envelope or wrapping the pipes with a synthetic filter creates a physical barrier. This envelope allows water to enter the drain while blocking fine silt and clay particles from migrating into and clogging the drainage system.

115. (B) Transition into sodic soils with degraded structure
Leaching saline-sodic soils with pure water removes soluble salts that keep clay particles flocculated. As salt concentration decreases, high levels of exchangeable sodium remain on the soil complex. This triggers clay swelling and dispersion, sealing soil pores, destroying structure, and turning the soil into a poorly permeable, classic sodic soil with high alkalinity.

116. (D) $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + H_2O + CO_2$
Agricultural lime neutralizes active acidity, which is represented by hydrogen ions in the soil solution. Calcium carbonate reacts with these hydrogen ions to yield soluble calcium ions, water, and carbon dioxide gas. This chemical pathway effectively consumes the active hydrogen ions, thereby raising the overall pH of the treated acid soil system.

117. (A) Rising water tables due to inadequate drainage
Secondary salinization in canal-irrigated regions occurs when excess irrigation water and seepage from unlined canals recharge the aquifer. Without adequate natural or artificial drainage, the groundwater table rises close to the surface. Capillary action then pulls this water upward, evaporating at the surface and leaving behind concentrated crusts of soluble salts.

118. (C) Amaranthaceae (including Chenopodiaceae)
The plant family Amaranthaceae, which historically includes the Chenopodiaceae, contains the highest proportion of specialized extreme halophytic species. These plants possess advanced physiological adaptations, such as salt glands, bladder cells, and internal osmotic

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98. (D) Extract moisture from the capillary fringe of the water table
Selecting deep-rooted trees is vital for bio-drainage systems in waterlogged areas. Deep roots allow the trees to access and extract water from the capillary fringe directly above the water table. This continuous transpirational uptake lowers the groundwater table, restoring aeration to the upper soil horizons for shallow-rooted crops.

99. (A) Hydraulic conductivity
The performance and spacing design of subsurface drainage systems are highly dependent on the soil's hydraulic conductivity. This physical property determines the rate at which water flows through the soil matrix toward drainage pipes. Soils with high hydraulic conductivity drain rapidly, allowing wider drain spacing than dense, heavy clay soils.

100. (A) I and III
Boron toxicity is prevalent in arid areas irrigated with saline water, while sodium toxicity directly impairs chlorophyll and chloroplast structures. However, chloride toxicity symptoms typically appear first on older, mature leaves because the ion accumulates at the ends of the transpiration stream over time, meaning the second statement is incorrect.

101. (A) Adequate subsurface drainage to remove the leachate
Reclaiming saline soils requires leaching soluble salts out of the root zone with high-quality water. However, this process is ineffective without adequate subsurface drainage. Without drainage, the added water simply raises the water table, bringing dissolved salts back to the surface via capillary action as evaporation occurs.

102. (D) Residual Sodium Carbonate
Residual Sodium Carbonate is the primary metric used to evaluate the hazard of high bicarbonate levels in irrigation water. When water contains excessive bicarbonate, it reacts with dissolved calcium and magnesium, precipitating them as insoluble carbonates. This precipitation increases the relative sodium concentration, elevating the sodicity hazard.

103. (B) Reduce net salinity below the crop tolerance threshold
Blending saline water with fresh water is a practical irrigation strategy used to increase usable water resources. By mixing these two sources, the total concentration of dissolved salts is diluted. This process reduces the net salinity of the irrigation water below the specific tolerance threshold of the target crop.

104. (C) Boron
Boron is an essential micronutrient, but the margin between deficiency and toxicity is extremely narrow. In salt-affected environments, particularly in arid regions, boron often accumulates to high concentrations in the soil solution. This excess boron is absorbed by crops, causing tissue necrosis, restricted development, and significant yield losses.

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105. (D) Micronutrient deficiencies
Over-liming acid soils raises the soil pH too rapidly or excessively, shifting the chemical equilibrium of the soil solution. This elevated pH dramatically reduces the solubility of essential micronutrients, particularly iron, manganese, zinc, and boron. Consequently, plants suffer from severe micronutrient deficiencies, which can cause chlorosis and stunted growth.

106. (C) Depletion of carbohydrate reserves
True submergence stress forces plants into an anaerobic state under water, where they rely on anaerobic respiration to survive. Because anaerobic pathway glycolysis is highly inefficient compared to aerobic respiration, plants rapidly consume their stored starch and sugars. This accelerated glycolysis leads to the swift depletion of internal carbohydrate reserves, severely limiting long-term survival.

107. (D) Green manure
Green manure crops decompose in the soil to release carbon dioxide and organic acids. Carbon dioxide dissolves in soil water to form carbonic acid, which reacts with calcium carbonate in calcareous soils to release soluble calcium. This increased calcium solubility enhances the exchange of sodium ions on the clay complex, improving gypsum reclamation efficiency.

108. (A) Saturated soil under negative pressure
The capillary fringe is the subsurface layer located immediately above the water table. In

88. (C) Prosopis juliflora
Prosopis juliflora is a highly resilient woody species naturally adapted to extreme soil conditions. It serves as a biological indicator of highly alkaline and sodic soils in northern India. The species survives high ESP and pH levels, actively contributing to soil amelioration by adding organic matter and lowering subsurface soil pH.

89. (D) Iron sulfides
Acid sulfate soils develop under waterlogged, anaerobic conditions where iron sulfides, primarily pyrite, accumulate. When these soils are artificially drained or exposed to air, aerobic conditions cause the rapid oxidation of these iron sulfides. This chemical reaction produces sulfuric acid, which drops the soil pH to extremely acidic levels.

90. (A) Both A and R are true and R is the correct explanation of A.
Basic slag is a highly effective byproduct used for reclaiming acid soils. It contains calcium and magnesium silicates, which act as basic agents to neutralize active soil acidity and raise pH. Additionally, it serves as a valuable supplementary source of phosphorus, which is typically highly fixed and deficient in acidic environments.

91. (B) Cation Exchange Capacity (CEC)
Calculating the Exchangeable Sodium Percentage requires two primary laboratory measurements. It is determined by dividing the concentration of exchangeable sodium by the total cation exchange capacity of the soil, then multiplying by one hundred. This metric indicates the proportion of the soil exchange complex occupied by sodium ions.

92. (B) Oxisols
Oxisols are highly weathered soils characteristic of ancient, stable landscapes in humid tropical regions. These soils have undergone intense weathering and leaching, leaving behind a highly depleted exchange complex dominated by insoluble iron and aluminum oxides. Consequently, Oxisols exhibit strong soil acidity, low base saturation, and severe phosphorus fixation.

93. (A) Integrating surface water and groundwater resources to optimize availability
Conjunctive use is an integrated water management strategy that coordinates the utilization of surface water and groundwater resources. By blending or alternating these sources, water managers can optimize overall water availability, control rising water tables, mitigate localized waterlogging, and prevent aquifer depletion while meeting crop irrigation requirements.

94. (C) Complete submergence
The Sub1A gene is a major genetic locus identified in specific flood-tolerant rice varieties. It regulates hormone pathways under water, allowing the plant to enter a dormant state during complete submergence. This prevents energy depletion and elongation growth, enabling the rice crop to survive fully submerged for up to two weeks.

95. (D) Dispersion
Soil dispersion is a physical degradation process driven by high exchangeable sodium concentrations. Sodium ions have a large hydrated radius that increases the electrostatic repulsion between clay particles. This repulsion forces soil aggregates to break apart into individual primary particles, which clog macropores and destroy soil structural stability.

96. (C) Waterlogging and reducing conditions
Manganese toxicity in strongly acidic soils is highly exacerbated by waterlogging. When soils become saturated, anaerobic conditions develop, prompting microbially-mediated reduction reactions. Insoluble manganic manganese is reduced to highly soluble and plant-available manganous forms, which can rapidly accumulate to phytotoxic levels within crop tissues.

97. (B) Active acidity is in soil solution; exchangeable is on colloids.
Active acidity and exchangeable acidity represent distinct pools of hydrogen and aluminum ions. Active acidity is measured directly in the soil solution and represents the immediate chemical environment of plant roots. In contrast, exchangeable acidity comprises ions held electrostatically on soil colloids, which buffer the active pool.

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adjustments. They are uniquely suited for cultivation and ecological restoration on severely salt-affected and degraded agricultural soils.

119. (A) Improve soil drainage via root penetration and add organic matter
Deep-rooted tree species in silvipastoral systems break through dense, impermeable sodic soil layers. Their extensive root systems create biological macro-channels that greatly enhance water infiltration and drainage. Furthermore, these trees continually deposit leaf litter and organic matter, which enhances microbial activity, increases carbon sequestration, and facilitates the natural reclamation of sodic lands.

120. (D) I, II and IV
Waterlogging creates anaerobic conditions that inhibit aerobic root respiration and restrict energy-dependent nutrient uptake of nitrogen, phosphorus, and potassium. Tissue ethylene concentrations rise rapidly under water, signaling the formation of aerenchyma to transport oxygen. However, stomatal conductance decreases rather than increases during prolonged flooding stress as a protective mechanism against leaf desiccation.

121. (B) Dissolved organic matter deposits as a dark surface crust
Sodic soils are historically termed black alkali due to their extremely high pH and sodium content, which disperse soil organic matter. This dispersed humic material dissolves and migrates upward with evaporating capillary water. Upon reaching the surface, the organic matter precipitates, leaving a characteristic dark, blackish crust across the soil surface.

122. (C) Hydrogen sulfide gas
Waterlogged soils undergo sequential reduction when oxygen is depleted. Once alternative electron acceptors like nitrate, manganese, and iron are consumed, obligate anaerobic bacteria utilize sulfate as a terminal electron acceptor. This metabolic reduction process converts sulfate into hydrogen sulfide gas, which is highly toxic to plant roots and produces a characteristic rotten-egg odor.

123. (D) Cation exchange capacity
The quantity of gypsum required to reclaim sodic soils is calculated based on replacing exchangeable sodium with calcium. This requirement depends on the exchangeable sodium percentage and the soil's cation exchange capacity. A higher cation exchange capacity means the soil can hold more total exchangeable sodium, thus requiring larger amounts of gypsum.

124. (A) Permeability Index (PI)
The Permeability Index evaluates the long-term risk that irrigation water poses to soil physical properties. This index incorporates the concentrations of sodium, calcium, magnesium, and bicarbonate to predict changes in soil permeability. High index values suggest potential structural problems, as certain ionic balances promote clay dispersion and subsequently clog the soil pore network.

125. (B) High pH tolerance, nitrogen fixation, and acidic biomass addition
Dhaincha is a highly resilient green manure crop suited for reclaiming sodic soils. It tolerates elevated soil pH and waterlogging while fixing atmospheric nitrogen to enrich soil fertility. When incorporated into the soil, its decomposing biomass releases carbon dioxide and organic acids, which lower soil pH and dissolve calcium carbonate to displace sodium.

126. (B) Sow seeds on the sloping side of the ridge
Under saline irrigation, soluble salts move upward with capillary water and accumulate heavily on the top center of raised beds or ridges. Sowing seeds on the sloping side of the ridge keeps the germinating seedlings away from this zone of highest salt concentration, ensuring better establishment and reducing osmotic stress during early growth.

127. (A) Soil dispersion and degraded physical structure
High levels of exchangeable magnesium on the soil clay complex behave similarly to exchangeable sodium in certain clay mineralogies. Excessive magnesium weakens the cohesive forces between clay platelets, causing soil dispersion and swelling when wet. This process destroys soil aggregates, seals pore spaces, reduces aeration, and severely degrades the overall physical structure.

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128. (C) Measuring the electrochemical activity of a specific ion
Ion-selective microelectrodes are designed to measure the electrochemical activity of a target ion in a solution or soil matrix. Unlike methods that measure total concentration, these sensors

68. (C) Lower the water table and facilitate salt leaching
Agricultural subsurface drainage systems are installed to manage both water logging and soil salinity. By providing an underground pathway for water movement, these systems lower a high water table below the root zone. This water table control improves soil aeration and facilitates the downward leaching of accumulated soluble salts.

69. (A) Heavy clay soils with high structural stability
Mole drains are unlined underground channels formed by pulling a dome-shaped steel plug through the soil. These drains are highly effective and durable in cohesive clay soils that possess high structural stability. In contrast, sandy or coarse-textured soils lack the cohesion required to maintain the stability of these unlined channels, causing rapid collapse.

70. (D) Depth of water removed from the drainage area in 24 hours
The drainage coefficient is a fundamental hydraulic design parameter for agricultural drainage networks. It is defined as the depth of excess water that must be removed from a specific drainage area within a twenty-four-hour period. This value determines the capacity and sizing of drainage channels, pipes, and pumping stations.

71. (B) Optimal spacing between lateral drains
Hooghoudt's equation is a classical steady-state drainage formula used in agricultural engineering. It relates soil properties, such as hydraulic conductivity, and hydrological inputs to calculate the optimal spacing between parallel subsurface lateral drains. This calculation ensures that the water table is maintained at a safe depth for crop production.

72. (C) Perforated PVC or PE
Modern subsurface drainage systems rely heavily on corrugated plastic pipes made from polyvinyl chloride or polyethylene. These materials are highly durable, resistant to chemical degradation, and lightweight, which simplifies installation. The pipes are perforated to allow water entry while preventing soil particles from clogging the drainage system.

73. (D) Transpirational withdrawal of groundwater by deep-rooted trees
Bio-drainage is a biological land reclamation technique that utilizes the natural water-pumping capacity of vegetation. Deep-rooted, salt-tolerant trees extract large volumes of water directly from a shallow water table. This continuous transpirational withdrawal lowers the localized water table, improving soil aeration and reducing waterlogging without the need for engineering structures.

74. (A) Eucalyptus species
Eucalyptus species are widely utilized for bio-drainage applications in waterlogged regions of India. These trees possess exceptionally high luxury transpiration rates, rapid growth, and deep, extensive root systems. These biophysical traits allow them to act as effective biological pumps, lowering water tables along canals and in low-lying agricultural depressions.

75. (A) P-2, Q-1, R-4, S-3
Alternate land-use systems utilize degraded lands through integrated ecological approaches. Halophyte cultivation involves growing specialized salt-accumulating plants, while silvipastoral systems integrate woody perennials with forages crops and livestock. Agroforestry combines crops with protective tree species, and aquaculture integration utilizes brackish water ponds to rear aquatic organisms on salt-affected soils.

76. (B) Halophyte cultivation for oil and biomass
Salicornia species are highly specialized halophytic plants capable of thriving in hyper-saline environments. They are ideal for alternate land-use systems on severely degraded soils where conventional crops fail. These plants accumulate salts within their tissues and produce oil-rich seeds and abundant biomass, offering economic value under extreme salinity.

77. (A) Leptochloa fusca
Leptochloa fusca, commonly known as Kallar grass, is a highly salt-tolerant grass species. It serves as a pioneer colonizer in silvipastoral systems established on highly sodic soils. It tolerates extreme alkali conditions and helps reclaim the soil biologically by improving organic matter, root penetration, and facilitating the dissolution of native calcium carbonate.

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support their respiration. This pathway reduces nitrate step-by-step, releasing nitrogen back into the atmosphere primarily as nitrous oxide and dinitrogen gases, resulting in significant nutrient loss.

139. (D) Variable, pH-dependent charge
Highly weathered tropical acid soils, such as Oxisols and Ultisols, are dominated by kaolinite clay and iron or aluminum oxides. These minerals have few isomorphic substitutions and instead possess variable, pH-dependent charge on their surfaces. Consequently, their cation and anion exchange capacities change significantly in response to shifts in soil solution pH.

140. (A) I, II, III and IV
Evaluating liming materials requires determining chemical purity, neutralizing value, particle size fineness, and moisture content. Chemical purity and neutralizing value dictate the acid-neutralizing capacity per unit weight. Fineness determines the rate of dissolution and reaction in the soil, while moisture content directly affects transportation costs and actual active ingredient application rates.

141. (B) Particle size of the limestone decreases
The rate of chemical reaction of agricultural limestone in neutralizing soil acidity is highly dependent on its total surface area. When the particle size of the limestone decreases, the contact area between the calcium carbonate and soil water increases exponentially. This allows the lime to dissolve rapidly and accelerate the neutralization of active acidity.

142. (B) Bronzing of the leaves
Iron toxicity in flooded rice fields occurs when strongly reducing conditions convert insoluble ferric iron to soluble ferrous iron. High uptake of ferrous iron produces reactive oxygen species that damage plant cells. This physiological stress manifests visually as a characteristic bronzing or tiny brown spotting on the leaves, starting from the tips.

143. (A) Mole drainage
Mole drainage is a subsurface system designed for cohesive, clay-rich soils. It utilizes a specialized tractor-drawn implement to pull a bullet-shaped metal plug through the subsoil. This action forms unlined, stable, cylindrical channels that act as artificial pathways, allowing excess water to flow out of the root zone and improve field drainage.

144. (C) Acid sulfate soils
Coastal mangrove swamps are rich in organic matter and dissolved sulfate, creating an ideal environment for the microbial formation of iron sulfides. When these wetlands are drained for agriculture, oxygen penetrates the soil and oxidizes the stable pyrites. This oxidation reaction produces sulfuric acid, drastically lowering the soil pH and forming acid sulfate soils.

145. (D) Providing an internal pathway for oxygen diffusion from shoots to roots
Aerenchyma is a specialized parenchymal tissue characterized by large, interconnected intercellular gas spaces. This anatomical adaptation provides a low-resistance internal pathway that allows oxygen to diffuse from the aerial parts of the plant down to the flooded root system. This oxygen supply sustains aerobic root respiration and oxidizes the surrounding rhizosphere under waterlogged conditions.

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146. (C) Increasing the standard seed rate by 20-25%
Saline soils impose osmotic and specific ion stresses that significantly lower the germination percentage and slow seedling emergence. To compensate for this anticipated reduction in plant stand and ensure an optimal crop density in the field, it is highly recommended to increase the standard seed rate by twenty to twenty-five percent during sowing.

147. (B) Sodic (alkali) soil
In pedological soil classification, particularly the Russian soil classification system, the term solonetz is used to describe sodic or alkali soils. These soils are characterized by a high exchangeable sodium percentage and a distinctive columnar subsoil structure. This structure forms due to clay dispersion and migration down the soil profile under highly alkaline conditions.

148. (D) Low storage capacity and slow recharge rates
Hard-rock aquifers are characterized by secondary porosity, where water is stored only in localized fractures, joints, and weathered zones. Consequently, these aquifers possess very low overall storage capacity and experience slow recharge rates. Intensive pumping quickly depletes groundwater reserves, leading to steep

inputs to feed all farm livestock animals
(D) By maximizing the export of raw crop biomass directly to external commodity markets

2013
8. Match the soil health parameter in List I with its corresponding characteristic in List II:

List I: (Soil Health Parameter)
P. Soil Bulk Density
Q. Cation Exchange Capacity
R. Soil Microbial Biomass
S. Soil Structure

List II: (Characteristic)
1. Aggregation of soil particles
2. Active biological component
3. Physical compaction indicator
4. Nutrient retention ability

(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-2, S-3

2016
9. Identify the INCORRECT statement regarding the preparation of vermicompost.
(A) Earthworms require an optimal moisture level of 60 to 70 percent in the bedding material.
(B) The temperature of the compost pit should ideally be maintained between 20 and 30 degrees Celsius.
(C) Epigeic earthworm species like Eisenia fetida are most commonly used for this process.
(D) Direct, intense sunlight accelerates the vermicomposting process by warming the worms.

2021
10. Which among the following is considered a concentrated organic manure rather than a bulky organic manure?
(A) Groundnut oil cake
(B) Farmyard Manure (FYM)
(C) Rural compost
(D) Green leaf manure

2003
11. Which of the following correctly pairs a biofertilizer with its primary functional mechanism?
(A) Azotobacter : Symbiotic nitrogen fixation within root nodules of legume crops
(B) Phosphate Solubilizing Bacteria : Solubilizing rock phosphate to orthophosphate
(C) Rhizobium : Asymbiotic nitrogen fixation in rhizosphere of dryland cereal crops
(D) Azolla : Direct solubilization of mineral potassium reserves from soil particles

2024
12. Consider the following statements regarding the methanogenesis phase in a biogas plant:
I. It is an aerobic process occurring at the surface of the slurry.
II. Methanogenic bacteria convert acetic acid and hydrogen into methane.
III. It operates optimally at extreme acidic pH levels below 4.0.
Which of the above statements is/are correct?
(A) I and II
(B) II
(C) II and III
(D) I

2009
13. Which of the following Indigenous Technical Knowledge (ITK) formulations is specifically prepared using cow dung, cow urine, milk, curd, and ghee?
(A) Panchagavya
(B) Jeevamrutha
(C) Beejamrutha
(D) Dashaparni Kashayam

2003
14. What role do endogeic earthworms primarily play in the organic nutrient recycling process?
(A) They live entirely on the soil surface and rapidly consume fresh leaf litter.
(B) They create deep vertical burrows and incorporate organic matter deep into the soil profile.
(C) They feed on subsurface soil and organic matter, promoting horizontal structural aggregation.
(D) They remain inactive in soil and exclusively secrete antibiotics to suppress fungal pathogens.

2014
15. The stale seedbed technique is an agronomic weed management strategy. How does it primarily function?
(A) By deeply burying weed seeds below the tillage depth so they are physically prevented from ever germinating
(B) By applying highly concentrated organic mulches that act to chemically burn down existing weed foliage

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159. (A) Alternative cropping strategies based on flood timing and duration
Contingent crop planning in waterlogged and flood-prone ecosystems involves preparing alternative farming strategies to mitigate weather risks. This approach defines specific crop choices, planting times, and management practices that can be deployed based on the actual arrival, duration, and depth of seasonal floods, ensuring some agricultural productivity under variable climate conditions.

160. (C) Elemental sulfur
Elemental sulfur is an effective amendment for lowering soil pH in highly calcareous soils. When applied to the soil, specialized autotrophic bacteria oxidize the sulfur to form sulfuric acid. This acid neutralizes carbonate minerals and reduces the soil pH, which significantly increases the solubility and biological availability of critical micronutrients like iron and zinc.

161. (D) Precipitate as mottles and concretions in the profile
Prolonged waterlogging creates highly reducing conditions, converting iron and manganese into their mobile, soluble reduced forms. When the soil is drained and re-aerated, oxygen levels rise rapidly. This transition causes these soluble metals to oxidize back into their insoluble forms, precipitating within the soil matrix as distinct, visible red-brown and black mottles or concretions.

162. (C) 1:1 or 1:2.5
The diagnostic assessment of salt-affected soils requires measuring pH in a standardized soil-water suspension. The most widely accepted and common laboratory procedures specify preparing this suspension using a soil-to-water ratio of either one-to-one or one-to-two-point-five. This consistent ratio ensures reproducible measurements of active acidity and alkalinity across different soil types.

163. (B) Biodrainage, nutrient cycling, and organic matter addition
Integrating agroforestry systems into problematic lands facilitates ecological reclamation through multiple mechanisms. Deep-rooted tree species act as biological pumps, transpiring large volumes of water to lower shallow water tables. Additionally, these systems enhance nutrient cycling from deep soil layers and deposit significant amounts of organic litter, which improves soil structure and fertility.

164. (D) Iron and aluminum oxides
Strongly weathered tropical soils are highly depleted of silicate minerals due to intense leaching. These soils are dominated by kaolinite and highly stable iron and aluminum oxides. Under acidic conditions, the surfaces of these oxides acquire positive charges by associating with hydrogen ions, providing the soil with its characteristic anion exchange capacity.

165. (A) Require aerobic, moist conditions for microbial oxidation
Iron pyrite is a valuable chemical amendment for reclaiming sodic soils, but it behaves differently than gypsum. Unlike highly soluble gypsum, pyrite is insoluble in water and must undergo microbial oxidation by thiobacilli to produce sulfuric acid. This biochemical process strictly requires aerobic, moist, and well-aerated soil conditions, which limits its initial effectiveness.

166. (C) Ethylene and Gibberellin
Deepwater rice exhibits a unique adaptation that allows it to survive rapid flooding by elongating its internodes. This rapid growth response is regulated by a complex hormonal interaction. Submergence traps ethylene inside the plant tissue, which triggers a decrease in abscisic acid and stimulates the synthesis and sensitivity to gibberellin, driving cell elongation.

167. (A) Secondary salinization
Secondary salinization describes the accumulation of soluble salts in the root zone due to human activities, primarily irrigation. When irrigation water containing dissolved salts is applied repeatedly to fields with inadequate drainage, plants transpire pure water while leaving the salts behind. Over time, these salts concentrate, severely degrading agricultural productivity.

168. (D) Without exceeding long-term average recharge to avoid depletion
The sustainable yield of a groundwater basin is an essential water resource management concept. It is defined as the maximum volume of groundwater that can be extracted annually over a long period without causing undesirable outcomes. This limit is set to match the long-term natural recharge rate, preventing progressive aquifer depletion and water quality degradation.

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189. (B) Saline seepage impacting adjacent fertile lands and aquifers
A major environmental risk associated with large-scale inland saline aquaculture is the lateral and vertical seepage of highly saline water from rearing ponds. If these ponds are unlined, the saline water can infiltrate adjacent fertile agricultural fields and contaminate shallow freshwater aquifers. This seepage degrades local soil quality and compromises regional drinking water supplies.

190. (B) Necrosis at margins and tips of older leaves
Boron is carried passively by the transpiration stream and accumulates primarily in the areas where water evaporates most rapidly from the plant. Consequently, specific boron toxicity manifests as a characteristic necrosis at the margins and tips of older leaves. This damage progresses inward, leading to premature leaf senescence and reduced photosynthetic capacity.

191. (A) Carbon dioxide
When calcium carbonate is applied to reclaim acid soils, it reacts with the active acidity represented by hydrogen ions in the soil solution. This neutralization reaction breaks down the carbonate ions, producing water and soluble calcium while releasing carbon dioxide gas. The evolution of carbon dioxide indicates the successful chemical consumption of active hydrogen ions.

192. (C) Bray's No. 1 extractant (Dilute acid-fluoride)
In highly acidic soils, phosphorus is strongly bound as insoluble iron and aluminum phosphates. To estimate plant-available phosphorus, Bray's Number One extractant, composed of dilute ammonium fluoride and hydrochloric acid, is recommended. The fluoride ions complex with aluminum, while the acid dissolves iron phosphates, releasing the bound phosphorus into the solution for measurement.

193. (A) Keep the pyrite-rich layers continuously saturated
Reclaiming acid sulfate soils requires careful water table management to control the oxidation of iron pyrites. The water table should be managed to keep the pyrite-rich subsurface layers continuously saturated with water. This saturation prevents atmospheric oxygen from contacting and oxidizing the pyrites, thereby blocking the biological and chemical production of highly toxic sulfuric acid.

194. (C) Has a higher salt threshold level and lower rate of yield decline
Barley is highly preferred over wheat in saline areas because it exhibits a superior genetic tolerance to salinity. It possesses a higher salt threshold level, meaning it can tolerate greater concentrations of soluble salts before experiencing yield loss. Additionally, barley displays a much lower rate of yield decline as soil salinity increases beyond this threshold.

195. (A) II, III, I
Soil texture determines the rate of water movement and the ease of sub-surface drainage. Loamy sand has large macropores and drains rapidly, requiring minimal drainage infrastructure. Silt loam has moderate permeability and requires intermediate spacing. In contrast, heavy clay has very low hydraulic conductivity and drains slowly, requiring highly intensive, closely spaced drainage networks.

196. (D) USSL Classification System
The United States Salinity Laboratory classification system offers a comprehensive framework for assessing irrigation water quality. It evaluates both the salinity hazard and the sodium hazard. By integrating these parameters with the specific salt tolerances of different crop groups, this system provides a reliable guide for selecting appropriate water management practices under diverse agricultural conditions.

197. (A) Compare stress yield to maximum yield under non-saline conditions
In salinity research, relative yield is a standard parameter used to evaluate crop salt tolerance. It is calculated by comparing the crop yield obtained under saline stress conditions to the maximum potential yield achieved under non-saline, optimal conditions. This ratio allows researchers to standardize and compare the stress responses of different crop cultivars.

198. (C) Seawater intrusion into freshwater coastal aquifers
Excessive groundwater extraction in coastal agricultural areas lowers the freshwater hydraulic head relative to the sea. This reduction in pressure allows dense saltwater from the ocean to migrate inland, leading to seawater intrusion

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179. (B) Precipitating calcium and magnesium, increasing the relative sodium
High concentrations of dissolved carbonate and bicarbonate ions in irrigation water present a structural hazard. When this water is applied to soil, these anions react with soluble calcium and magnesium, causing them to precipitate as insoluble carbonates. This precipitation reduces the active concentrations of divalent cations, effectively increasing the relative proportion of sodium.

180. (D) Dissolution of gypsum → Displacement of exchangeable sodium by calcium → Leaching of sodium sulfate
Chemically reclaiming a sodic soil using gypsum involves a specific sequence of reactions. First, the applied gypsum dissolves in soil water to release calcium ions. Next, these calcium ions displace toxic exchangeable sodium from the clay cation exchange sites. Finally, the displaced sodium reacts with sulfate, forming highly soluble sodium sulfate, which is leached downward.

181. (A) Non-saline sodic soil
Soil classification guidelines identify a soil with an exchangeable sodium percentage greater than fifteen and an electrical conductivity less than four decisiemens per meter as a non-saline sodic soil. In this specific case, the soil exhibits high sodium saturation on the exchange complex but contains low levels of total soluble salts in the solution.

182. (C) Calcium
Soils with a high Sodium Adsorption Ratio possess excessive levels of exchangeable and soluble sodium relative to divalent cations. This high concentration of sodium competitively inhibits the uptake of calcium by plant roots. Consequently, crops grown in these high-SAR soils frequently suffer from severe nutritional deficiencies of calcium, leading to disrupted cell wall development.

183. (A) Critical water table depth
The critical water table depth is a key engineering parameter in drainage design. It represents the minimum depth to which the water table must be lowered and maintained to prevent waterlogging and salt accumulation in the root zone. Ensuring this depth protects crop roots from oxygen starvation and prevents the capillary rise of saline water.

184. (D) Clay and organic matter
The buffer capacity of an acid soil refers to its ability to resist changes in pH when lime is applied. This buffering capacity is directly determined by the soil's content of clay and organic matter. These components provide exchange sites that hold reserve acidity, meaning soils with high clay or organic matter require more limestone.

185. (B) Mixing fresh and saline waters to achieve a safe salinity level
Conjunctive water management optimizes the use of saline and fresh water resources for irrigation. Blending specifically refers to mixing high-salinity brackish water with good-quality fresh water in a controlled ratio before application. This practice dilutes the salt concentration to a safe level, reducing the osmotic and toxic impacts of saline water on crops.

186. (C) Retention of sodium in roots and lower stem tissues
Salt-excluder plants employ sophisticated physiological mechanisms to protect their highly sensitive photosynthetic tissues from toxic ions. A common trait is the selective retention of sodium and chloride ions within the roots and lower stem structures. This prevents these toxic ions from being translocated upward into the newly developing leaves and reproductive organs.

187. (D) Humid region acid soils
Humid regions experience high annual rainfall that exceeds evapotranspiration. This surplus water percolates down the soil profile, leaching away soluble basic cations like calcium, magnesium, and potassium. As these basic cations are lost, acidic cations such as hydrogen and aluminum dominate the exchange complex, resulting in the formation of humid region acid soils.

188. (A) The redox (oxidation-reduction) potential
In waterlogged ecosystems, the term E_h represents the redox or oxidation-reduction potential of the soil. This thermodynamic parameter measures the tendency of the soil environment to transfer electrons. Monitoring E_h is crucial because it indicates the oxygen status of the soil and dictates the chemical speciation and availability of nutrients and toxic metals.

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water table declines and long-term depletion challenges.

149. (A) 1 N Potassium Chloride
Exchangeable aluminum is a major source of acidity and toxicity in highly acid soils. To measure this pool, the soil is extracted using an unbuffered salt solution, typically one normal potassium chloride. The potassium ions displace the electrostatic bound aluminum ions from the exchange complex into the solution, where they are quantified by titration.

150. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Plants in saline soils often experience physiological drought despite the presence of physical water in the soil. High concentrations of dissolved salts lower the osmotic potential of the soil solution below that of the root cells. This osmotic barrier restricts the ability of roots to absorb water, inducing water stress identical to drought conditions.

151. (A) Drip (trickle) irrigation
Drip irrigation is highly efficient for saline water management because it applies water slowly and frequently directly to the root zone. This frequent application maintains high soil matric potential, keeping the salt concentration diluted near the roots. Furthermore, by avoiding wetting the foliage, drip systems eliminate the risk of direct foliar salt absorption and leaf burn.

152. (D) Electrical Conductivity (EC))
The United States Salinity Laboratory diagram is a standard tool used to evaluate the suitability of irrigation water. The diagram plots the sodium hazard, represented by the Sodium Adsorption Ratio on the vertical axis, against the salinity hazard, represented by the Electrical Conductivity on the horizontal axis, to classify water into distinct quality classes.

153. (B) Causing swelling and dispersion of 2:1 lattice clays
High sodium levels in irrigation water replace calcium and magnesium on the soil cation exchange complex. This excessive sodium increases the thickness of the diffuse double layer around clay particles, causing swelling and dispersion of 2:1 lattice clays. The dispersed clay particles migrate and clog the soil macropores, severely restricting water and air permeability.

154. (C) Higher sensitivity of shoots than roots to salinity
Under salinity stress, plants experience a reduction in the shoot-to-root ratio. This occurs because leaf expansion and shoot growth are highly sensitive to both osmotic stress and toxic ion accumulation. Roots, being in direct contact with the soil, adjust their osmotic potential more effectively, allowing root elongation to continue even when shoot growth is suppressed.

155. (D) Cultivation of deep-rooted, acid-exuding grasses
Cultivating deep-rooted, acid-exuding grasses represents an indirect, biological reclamation strategy for sodic soils. These specialized grasses penetrate dense soil layers, improving physical structure and permeability. Their root systems exude organic acids and carbon dioxide into the rhizosphere, which helps dissolve native calcium carbonate, releasing soluble calcium to displace toxic exchangeable sodium.

NODIA

156. (A) Leaf tip burn and marginal necrosis
In woody perennial crops, chloride toxicity is a common problem because these plants accumulate chloride over time in their leaves. The initial visual symptoms typically present as leaf tip burn and marginal necrosis. As chloride continues to accumulate to toxic levels, these necrotic symptoms spread inward, leading to premature leaf drop and twig dieback.

157. (B) Removing soluble salts causes exchangeable sodium to disperse the soil
Leaching saline-sodic soils with low-salinity water without adding a calcium amendment like gypsum is highly detrimental. This process washes out the soluble salts that keep the soil clay flocculated. Once these salts are removed, the remaining high exchangeable sodium causes the clay to disperse immediately, sealing the soil pores and destroying its structural stability.

158. (B) Nutritional imbalance and direct toxicity from specific ions
The specific ion effect is a major component of salt stress in plants, distinct from osmotic stress. It refers to the direct toxicity and nutritional imbalances caused by the excessive uptake of specific ions, primarily sodium and chloride. These ions accumulate in plant tissues, disrupting cellular metabolism, inhibiting enzymes, and interfering with essential nutrient uptake.

into freshwater coastal aquifers. This intrusion salinizes local wells, rendering the groundwater unsuitable for both irrigation and human consumption.

199. (A) Capillary rise capacity of the soil profile increases
The contribution of shallow groundwater to crop water needs is driven by capillary forces. This contribution increases as the capillary rise capacity of the soil profile increases, which is higher in soils with well-distributed pore sizes. Under these conditions, water is drawn upward from the water table, delivering moisture directly to the active root zone.

200. (D) Procurement, transport, and application of chemical amendments
Reclaiming sodic soils requires replacing exchangeable sodium with calcium, which demands large applications of amendments like gypsum. Consequently, the procurement, transportation, and field application of these heavy chemical amendments usually constitute the highest initial capital cost. This high cost represents a major economic barrier for smallholder farmers attempting to restore degraded agricultural lands.

201. (B) Adopting stale seedbed techniques and early post-emergence control
Weed competition is highly intense in flood-prone environments because water dynamics stimulate weed seed germination. Adopting stale seedbed techniques, where weeds are allowed to emerge and are destroyed before planting, is highly effective. Combining this with early post-emergence weed control suppresses weed growth, giving the main crop a competitive advantage in the field.

202. (C) Salt imported via irrigation equals or is less than salt exported via drainage
A sustainable salt balance in an irrigated agricultural watershed requires preventing long-term salt accumulation in the soil profile. This balance is achieved when the total mass of soluble salts imported into the watershed via irrigation water is equal to or less than the total mass of salts exported out of the system through drainage networks.

203. (D) Manganese
Mine spoil soils are often highly acidic due to the oxidation of sulfide minerals. Under these extreme low-pH conditions, the solubility of several heavy metals and transition elements increases dramatically. Manganese is frequently observed in highly toxic concentrations in these disturbed soils, severely restricting plant growth and contaminating local surface and subsurface water resources.

204. (A) Narrow and closely spaced
In subsurface drainage design, the spacing between lateral drains is governed by the soil hydraulic conductivity. Heavy clay soils possess low horizontal saturated hydraulic conductivity, which restricts water movement toward the drains. To drain these soils effectively and prevent root zone waterlogging, the lateral drains must be installed at narrow and closely spaced intervals.

205. (B) Physical impedance of seedling emergence and root growth
Soils that form hard surface crusts when dry present a severe physical barrier to crops. The primary biological constraint in these crust-prone soils is the physical impedance of seedling emergence and early root growth. Germinating seedlings struggle to break through the compacted surface layer, resulting in poor stand establishment, uneven crop growth, and reduced yields.

206. (B) Adequate subsurface drainage with rational irrigation scheduling
Preventing secondary salinization in productive agricultural lands requires maintaining the water table well below the critical depth. Installing adequate subsurface drainage systems effectively removes excess water from the profile. Combining this drainage with rational, demand-based irrigation scheduling prevents waterlogging, controls capillary rise, and avoids the accumulation of soluble salts in the crop root zone.

207. (A) A proton gradient generated by vacuolar H+-ATPases
Halophytic plants actively transport toxic sodium ions out of the cytoplasm and into the vacuole to prevent cellular toxicity. This active transport is mediated by sodium-proton antiporters located on the tonoplast membrane. This process is

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169. (B) To leach surface salts below the seed germination zone
Applying a heavy pre-sowing irrigation with high-quality water is a vital practice in saline soils. This water dissolves the highly concentrated soluble salts present on the soil surface and leaches them deep into the soil profile. This process temporarily creates a low-salinity zone around the seeds, allowing successful germination and early seedling establishment.

170. (C) P-4, Q-2, R-3, S-1
Problem soils require distinct reclamation strategies. Sodic soils need gypsum to displace exchangeable sodium. Acid soils require agricultural limestone to neutralize active hydrogen ions. Acid sulfate soils require heavy liming combined with water table management to prevent pyrite oxidation. Saline soils without high sodium do not need chemical amendments; they require leaching and proper drainage.

171. (D) Reducing surface evaporation to minimize upward salt movement
Applying organic mulches on the surface of saline soils is a highly effective management practice. The mulch layer acts as a physical barrier that shields the soil from direct solar radiation and wind, significantly reducing surface water evaporation. This reduction in evaporation prevents the capillary rise of saline groundwater, minimizing the accumulation of salts.

172. (A) Sodium, Chloride, Boron
Specific ion toxicity hazards in irrigation water are primarily evaluated by measuring the concentrations of sodium, chloride, and boron. These three elements are readily absorbed by plant roots and transported to the foliage. When they accumulate to critical thresholds, they cause direct cellular damage, leaf necrosis, and severe metabolic disruptions in sensitive crops.

173. (B) The north-western plains (e.g., Haryana and Punjab))
Inland saline aquaculture has emerged as a highly profitable livelihood alternative in the north-western plains of India, particularly in Haryana and Punjab. These agricultural regions suffer from extensive waterlogging and secondary soil salinization caused by brackish groundwater and inadequate drainage. Utilizing this salty water for shrimp farming transforms unproductive lands into high-value systems.

174. (B) Pneumatophores
Pneumatophores are specialized, upward-growing lateral roots developed by many mangrove and wetland tree species. These roots emerge vertically out of the oxygen-depleted, waterlogged mud into the air. They possess numerous specialized pores called lenticels, which facilitate gas exchange and allow atmospheric oxygen to diffuse down to the submerged root tissues.

175. (A) Crop yield begins to decline below its maximum potential
The threshold salinity of a crop is a fundamental agronomic parameter. It represents the specific electrical conductivity of the saturated soil extract at which the crop yield first begins to decline below its maximum potential under non-saline conditions. Beyond this threshold, any further increase in soil salinity causes a linear decrease in crop yield.

176. (C) Compatible organic cell solutes
Halophytes cope with high salinity by compartmentalizing toxic sodium and chloride ions into their vacuoles. To prevent water from leaving the cytoplasm into the vacuole, these plants must balance the internal osmotic pressure. They achieve this by synthesizing compatible organic solutes, such as proline and glycine betaine, within the cytoplasm to maintain cellular turgor.

177. (D) $pH < 5.5$
Molybdenum is unique among micronutrients because its availability increases with soil pH. In strongly acidic soils with a pH below five-point-five, molybdenum anions are strongly adsorbed or fixed onto the surfaces of iron and aluminum oxides. This chemical immobilization severely restricts its availability, often inducing molybdenum deficiencies in susceptible crops like legumes.

178. (C) The pH of both soil types tends to converge toward neutrality.
Prolonged soil submergence triggers chemical and biological reduction reactions that alter soil pH. In acid soils, the reduction of iron oxides consumes hydrogen ions, causing the pH to rise. Conversely, in alkaline soils, the accumulation of dissolved carbon dioxide forms carbonic acid, lowering the pH. Consequently, the pH of both soil types converges toward neutrality.

NODIA

CHAPTER 14
Organic Farming

2006

1. Which of the following best defines the primary philosophy of organic farming as recognized in its historical evolution?
(A) A substitution of synthetic chemicals with natural minerals to maximize crop yields
(B) A production system promoting agro-ecosystem health, biodiversity, and soil activity
(C) A cultivation method utilizing unmanaged wild land to harvest traditional wild crops
(D) An integration of genetically modified organisms with natural nutrient-cycle systems

2022

2. When comparing regenerative agriculture to conventional organic farming, which objective is distinctively emphasized by regenerative practices?
(A) The substitution of chemical fertilizers with certified organic nutrient inputs
(B) A strict adherence to the complete avoidance of all synthetic chemical pesticides
(C) The reliance on monoculture cropping systems to achieve higher production efficiency
(D) The continuous improvement and restoration of degraded agricultural soil ecosystems

2010

3. Under the IFOAM principles of organic agriculture, the Principle of Fairness primarily dictates that organic agriculture should:
(A) Provide quality of life, food sovereignty, and poverty reduction
(B) Ensure high profit margins for intermediate agricultural brokers
(C) Focus solely on equitable water distribution among neighboring farms
(D) Guarantee equal crop yields across all certified organic farms

2001

4. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): India holds the highest number of organic producers globally, yet its total certified organic cultivated area ranks lower than that of Australia.
Reason (R): The majority of organic farmers in India are smallholder farmers with fragmented landholdings.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2021

5. During the establishment of an organic farm, a buffer zone is mandated. Which of the following is the most relevant reason for this requirement?
(A) Prevent unintended drift of synthetic chemicals from adjacent conventional fields
(B) Provide wild habitats for large mammalian pests and prevent their entry into crops
(C) Serve as an isolated zone dedicated exclusively to storing harvested organic produce
(D) Create a physical barrier against windblown weed species seeds spreading into the farm

2001

6. Which cropping practice involves planting a succeeding crop into a standing crop before the harvest of the latter, frequently used in organic systems to maintain soil cover?
(A) Ratoon cropping
(B) Strip cropping
(C) Monoculture cropping
(D) Relay cropping

2023

7. What is the fundamental mechanism by which an Integrated Organic Farming System (IOFS) enhances resource use efficiency?
(A) By isolating livestock and crop enterprises to prevent overlapping nutrient usage
(B) By utilizing the byproduct or waste of one enterprise as an input for another
(C) By relying entirely on off-farm composted

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driven energetically by a proton gradient, which is generated across the membrane by vacuolar H+-ATPases and inorganic pyrophosphatases.

208. (C) Exchangeable sodium down to a safe percentage
Laboratory estimation of the gypsum requirement of a sodic soil determines the amount of calcium needed to reclaim the soil. The method measures the calcium required to replace toxic exchangeable sodium on the soil clay complex and lower it to a safe level. This reduction improves soil physical properties, restores structural stability, and enhances water infiltration.

209. (D) Supplying commercial mineral mixtures rich in potassium and magnesium
Inland saline water used for aquaculture often lacks essential minerals, causing physiological stress in shrimp. To resolve this mineral deficiency and support osmoregulation, farmers supplement the water with commercial mineral mixtures. These mixtures are formulated with high levels of potassium and magnesium to restore the ionic balance, ensuring high survival rates and optimal shrimp growth.

210. (C) Achieve restoration, carbon sequestration, and sustainable returns
The long-term goal of integrating alternate land-use systems on problematic soils is to restore degraded ecosystems. Rather than relying on intensive, unsustainable annual cropping, these systems use perennial vegetation. This approach enhances soil organic carbon sequestration, improves physical and chemical soil properties, and generates sustainable, long-term economic returns for local farming communities.

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(C) By using highly selective botanical organic herbicides to completely sterilize the upper soil surface
(D) By letting early flushes of weeds germinate and then mechanically destroying them before crop sowing

2001

16. Which of the following is the correct sequence of the standard steps involved in the third-party organic certification process?
(A) Application submission → Field inspection → Review of farm records → Issuance of certificate
(B) Field inspection → Issuance of certificate → Application submission → Review of farm records
(C) Review of farm records → Application submission → Issuance of certificate → Field inspection
(D) Application submission → Issuance of certificate → Review of farm records → Field inspection

2001

17. Pyrethrin, a widely used botanical pesticide in organic farming, is extracted from the flowers of which plant?
(A) Azadirachta indica plant
(B) Chrysanthemum cinerariifolium
(C) Pongamia pinnata species
(D) Derris elliptica climber

2013

18. Trichoderma viride is applied in organic agriculture primarily for which of the following purposes?
(A) Biological control of leaf-eating lepidopteran pests
(B) Enhancement of crop resistance to environmental frost
(C) Direct biological fixation of atmospheric nitrogen
(D) Biological control of soil-borne fungal pathogens

2010

19. According to recent comparative studies, organically grown produce frequently exhibits higher concentrations of which biochemical compounds compared to conventionally grown produce?
(A) Secondary metabolites and antioxidants
(B) Synthetic chemical pesticide residues
(C) Heavy metals like cadmium and lead
(D) Free nitrate and nitrite compounds

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2003

20. Which post-harvest practice is strictly prohibited under National Programme for Organic Production (NPOP) guidelines for organic produce?
(A) Controlled atmosphere storage techniques
(B) Use of natural waxes derived from carnauba
(C) Ionizing radiation for shelf-life extension
(D) Forced-air cooling to remove field heat

2006

21. Which Indian statutory body serves as the national secretariat for the implementation of the National Programme for Organic Production (NPOP)?
(A) APEDA
(B) FSSAI
(C) ICAR
(D) NABARD

2014

22. In the Participatory Guarantee System (PGS-India), who primarily conducts the verification of farming practices to ensure adherence to organic standards?
(A) International independent auditors
(B) Government-appointed agricultural extension officers
(C) Representatives from global retail supermarket chains
(D) Local peer groups consisting of fellow farmers

2010

23. What is the fundamental purpose of the TraceNet traceability system in the Indian organic sector?
(A) To track and manage the migration patterns of agricultural labor
(B) To maintain an online registry tracing organic products to export
(C) To monitor and publish the global prices of synthetic fertilizers
(D) To track real-time weather fluctuations across agro-climatic zones

2014

24. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The biodynamic preparation BD-500 is typically applied to the soil rather than directly onto the plant foliage.
Reason (R): BD-500 is a silica-based preparation designed specifically to enhance photosynthesis and light metabolism in leaves.

2001

74. Which of the following statements correctly identifies the function of a trap crop in pest management?

(A) A crop grown to attract insects away from the main economic crop

(B) A crop that produces toxic exudates to eliminate soil-borne pathogens

(C) A crop genetically modified to trap flying insects using sticky leaves

(D) A highly competitive crop that traps all available soil moisture

2013

75. What is the most relevant indicator of biological activity and active organic matter decomposition in a compost pile?

(A) A sudden, rapid drop in pH below 4.0 within the first twenty-four hours

(B) A rise in internal temperature (thermophilic phase) reaching 55-65 degrees Celsius

(C) A steady, continuous decrease in moisture content down to zero percent

(D) The immediate appearance of massive earthworm populations in the central compost core

2011

76. Consider the following soil organic matter decomposition stages:

I. Humification of complex biopolymers

II. Colonization by primary saprophytic fungi and bacteria

III. Breakdown of simple sugars and water-soluble compounds

IV. Mineralization of stable humus into inorganic ions

Which of the following sequences represents the correct order of these stages?

(A) III, II, I, IV

(B) II, III, I, IV

(C) II, I, III, IV

(D) III, I, II, IV

2015

77. Which of the following is an advantage of using concentrated organic manures like neem cake?

(A) They contain nitrification-inhibiting properties while supplying steady nitrogen

(B) They provide highly soluble mineral phosphorus equivalent to commercial superphosphate

(C) They must be applied in massive bulk quantities to physically structure the topsoil

(D) They are completely devoid of any carbonaceous organic matter after processing

2025

78. Which statement best represents the function of Azospirillum as a biofertilizer?

(A) It forms distinct root nodules and works in obligate symbiosis with agricultural legume crops.

(B) It acts exclusively as a chemical phosphorus solubilizer under highly alkaline soil conditions.

(C) It is a free-living, associative microaerophilic bacterium fixing nitrogen in grasses and cereals.

(D) It is a water fern harboring symbiotic nitrogen-fixing cyanobacteria inside its leaf cavities.

2009

79. The slurry obtained as a byproduct from a functioning biogas plant is agronomically valuable because:

(A) It is completely sterile, dry, and entirely devoid of any residual soil organic matter.

(B) It contains extremely high concentrations of unfermented, phytotoxic organic acids.

(C) It rapidly increases soil bulk density, facilitating the formation of a hardpan layer.

(D) Its nitrogen is predominantly in a readily plant-available form compared to raw dung.

2022

80. In the preparation of Panchagavya, what is the specific role of the addition of jaggery or ripe bananas?

(A) To act as a highly concentrated chemical biocide designed to eliminate all baseline pathogens

(B) To increase the overall electrical conductivity and chemical salinity of the fermentation mixture

(C) To provide a readily available carbon source for rapid microbial multiplication

(D) To permanently halt the biochemical fermentation process once the organic mixture is prepared

2015

81. Which agricultural practice is an example of cultural weed management in organic farming?

(A) Application of synthetic pre-emergence chemical herbicides

(B) Adopting narrower row spacing to ensure early canopy closure

(C) Using a tractor-drawn mechanical rotavator

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(B) II, III and IV
(C) III
(D) I, II and IV

2012

33. Which characteristic differentiates relay cropping from standard multiple cropping sequences?
(A) Two crops are grown in alternate distinct rows without overlapping lifecycles.
(B) Seeds of the subsequent crop are sown before the harvest of the preceding crop.
(C) The field is left fallow for an entire season between consecutive crops.
(D) The second crop is planted only after the complete tillage of the harvested first crop.

2008

34. What is the fundamental cause of the initial nitrogen immobilization often observed when raw, undecomposed crop residues are applied to soil?
(A) Accumulation of high levels of naturally occurring soil antibiotics in the crop rhizosphere
(B) Direct physical volatilization of ammonia gases from the decomposing surface crop residues
(C) Rapid leaching of complex nitrogenous proteins into deep subsoil and groundwater systems
(D) Microbes consuming available soil nitrogen to decompose high $C{:}N$ ratio plant residues

2019

35. Which biological process is primarily responsible for the conversion of complex organic nitrogen in manures into plant-available ammonium?
(A) Mineralization
(B) Denitrification
(C) Nitrification
(D) Volatilization

2014

36. Consider the following steps of commercial compost preparation:
I. Selection of site and pit excavation
II. Layering of carbon-rich and nitrogen-rich materials
III. Harvesting and sieving of the stabilized compost
IV. Periodic turning for aeration and temperature regulation
Which of the following sequences represents the correct order of these steps?
(A) I, II, IV, III
(B) II, I, III, IV
(C) I, IV, II, III
(D) II, I, IV, III

2015

37. Which statement most accurately compares farmyard manure (FYM) with concentrated organic manures like oil cakes?
(A) FYM provides bulky organic matter, while oil cakes act primarily as concentrated nutrients.
(B) FYM possesses a much lower volume and higher concentration of nutrients than typical oil cakes.
(C) Oil cakes require several years to release nutrients, whereas FYM releases nutrients instantly.
(D) Both organic manures possess a completely identical carbon-to-nitrogen ratio upon application.

NODIA

2016

38. The symbiotic relationship between Azolla and Anabaena azollae is extensively utilized for nitrogen management in the cultivation of which crop?
(A) Wheat
(B) Sugarcane
(C) Cotton
(D) Rice

2025

39. Identify the INCORRECT pair of biofertilizer and its general application domain.
(A) Rhizobium : Legume seed treatment
(B) Azospirillum : Obligate symbiotic nodulation in maize
(C) Blue Green Algae : Flooded paddy fields
(D) Mycorrhizae : Root colonization for phosphorus uptake

2007

40. Which organic formulation relies on the concept of utilizing local cow dung, cow urine, undisturbed forest soil, jaggery, and pulse flour to multiply beneficial soil microflora?
(A) Panchagavya
(B) Amrit Pani
(C) Jeevamrutha
(D) Bokashi

2024

41. In an Integrated Organic Farming System (IOFS), how does the incorporation of poultry into a crop-based system directly benefit soil chemical health?

production

2021

57. Which biological indicator is most frequently used to assess the improvement of soil health in transitioning organic farms?
(A) Topsoil color profile
(B) Absolute sand percentage
(C) Soil bulk density value
(D) Earthworm population density

2024

58. Crotalaria juncea (Sunnhemp) is widely favored for in-situ green manuring primarily because of its:
(A) Rapid growth and high nitrogen accumulation
(B) Extremely slow decomposition rate
(C) High lignocellulosic content
(D) Resistance to all known soil pathogens

2003

59. What mechanism allows Phosphate Solubilizing Bacteria (PSB) to increase the availability of phosphorus to plants?
(A) They physically transport phosphorus from the subsoil using specialized fungal hyphae.
(B) They secrete organic acids that lower localized soil pH, dissolving bound phosphates.
(C) They convert atmospheric nitrogen into phosphorus through enzymatic transmutation.
(D) They absorb toxic metals, replacing them with pure phosphorus molecules.

2009

60. During the anaerobic digestion process in a biogas plant, which microbial group acts prior to the methanogens to break down complex polymers?
(A) Aerobic nitrifying bacteria
(B) Acidogenic and acetogenic bacteria
(C) Nitrogen-fixing cyanobacteria
(D) Autotrophic sulfur-oxidizing bacteria

2022

61. Beejamrutha is an ITK preparation used in organic farming specifically for which agricultural operation?
(A) Seed treatment prior to sowing
(B) Foliar application to deter leaf-eating caterpillars
(C) Post-harvest preservation of grains
(D) Weed eradication in standing water

2016

62. Which classification of earthworms is most appropriate for commercial vermicomposting due to their preference for organic surface litter?
(A) Anecic
(B) Endogeic
(C) Epigeic
(D) Geophagous

2006

63. Soil solarization is an ecological method of weed management that operates on the principle of:
(A) Flooding agricultural fields systematically to drown and suffocate emerging weed seedlings
(B) Using concentrated reflecting solar mirrors to directly burn down standing weed biomass
(C) Shading the soil surface completely with thick opaque materials to block photosynthesis
(D) Covering moist soil with clear plastic film to trap solar energy and heat weed seeds lethally

2019

64. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The botanical insecticide derived from Pyrethrum exhibits rapid knockdown effects on target insect pests.
Reason (R): Pyrethrins act as neurotoxins by prolonging the opening of sodium channels in the insect's nervous system.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2025

65. In biological pest management, how does a parasitoid differ from a predator?
(A) A parasitoid consumes many different prey items during its life, while a typical predator requires only one host.
(B) A parasitoid develops on or inside a single host, killing it, whereas a predator consumes multiple prey individuals.
(C) Parasitoids are botanical derivatives used to repel insects, whereas predators are living biological organisms.
(D) Predators are strictly active during nocturnal periods, while parasitoids hunt exclusively during daylight hours.

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government
(B) The specific phases of the moon and planetary positions
(C) The hourly price fluctuations of global commodity markets
(D) The daily barometric pressure variations in local weather

2002
50. What is an inherent socio-economic advantage of the Participatory Guarantee System (PGS) over standard third-party organic certification?
(A) It completely eliminates the administrative requirement of maintaining any crop records.
(B) It involves no peer review or group inspection, allowing absolute farmer certification autonomy.
(C) It automatically guarantees high premium prices in competitive international export markets.
(D) It significantly reduces the financial burden of certification costs for smallholder farmers.

2008
51. Which principle governs the calculation of Water Use Efficiency (WUE) in a crop production system?
(A) The ratio of crop economic yield to the total volume of water consumed
(B) The total seasonal rainfall received minus the surface runoff losses
(C) The depth of the underground water table at the time of crop harvesting
(D) The total volume of irrigation water applied divided by the farm area

2018
52. Consider the following statements regarding ecological farming:
I. It emphasizes the integration of ecological principles into agro-ecosystem management.
II. It promotes biodiversity, nutrient cycling, and soil conservation.
III. It strictly mandates the use of synthetic weedicides for ground cover management.
IV. It seeks to close nutrient loops by minimizing external inputs.
V. It focuses on the exclusive cultivation of cash crops for export.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II, III and V
(C) II, IV and V
(D) I, III and IV

2025
53. Which biological pest control strategy uses repellent companion crops to drive insect pests away from the main crop, while simultaneously planting attractive trap crops on the field border to lure them?
(A) Push-pull strategy
(B) Green manuring
(C) Blind hoeing
(D) Crop rotation

2018
54. According to IFOAM, the Principle of Health states that organic agriculture should sustain and enhance the health of:
(A) Only the individual final human consumer of the harvested organic crop product
(B) The livestock animals raised specifically for draft power and transport on farm
(C) The multinational corporate trading entities engaged in agricultural commodity markets
(D) Soil, plant, animal, human, and planet as one single and indivisible ecosystem

NODIA

2004
55. What is the fundamental difference between 'conversion period' and 'buffer zone' in organic farming standards?
(A) Conversion period is a spatial boundary, while a buffer zone is a temporal management phase.
(B) Conversion period is a time-based transition phase, while a buffer zone is a physical barrier.
(C) Both terms refer identically to the required biological resting period of soil between cycles.
(D) Conversion period applies only to livestock, while a buffer zone applies only to field crops.

2018
56. Which sequence correctly represents the flow of carbon in an ideal Integrated Organic Farming System (IOFS)?
(A) Crop residue → Livestock feed → Dung production → Composting → Field application
(B) Field application → Composting → Livestock feed → Crop residue → Dung production
(C) Dung production → Field application → Crop residue → Composting → Livestock feed
(D) Livestock feed → Field application → Composting → Crop residue → Dung

(A) By mechanically aerating and loosening the compact subsoil horizons during foraging
(B) By significantly lowering the ambient canopy temperature through shade and microclimate
(C) By actively extracting and bioaccumulating toxic heavy metals from the soil profile
(D) By providing highly concentrated nitrogen and phosphorus through their organic droppings

2024
42. What is the major active principle found in the botanical pesticide derived from the neem tree (Azadirachta indica)?
(A) Azadirachtin
(B) Rotenone
(C) Nicotine
(D) Cinerin

2012
43. Nuclear Polyhedrosis Virus (NPV) is a microbial biocontrol agent highly specific for managing which type of agricultural pests?
(A) Sucking insect pests including aphids and whiteflies
(B) Lepidopteran caterpillars such as Helicoverpa armigera
(C) Plant parasitic nematodes inhabiting the soil rhizosphere
(D) Soil-borne pathogenic fungi causing seedling damping-off

2015
44. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The use of synthetic urea is strictly prohibited in certified organic farming systems.
Reason (R): Synthetic urea is manufactured via the Haber-Bosch process, which relies heavily on non-renewable fossil fuels and contradicts natural cycling principles.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2015
45. Which physical technique utilizes a specialized implement to pass a flame rapidly over a stale seedbed to manage weed seedlings prior to crop emergence?
(A) Thermal weeding (flaming)
(B) Soil solarization method
(C) Blind tillage operation
(D) Surface organic mulching

2017
46. Under organic food safety aspects, what is a primary concern effectively minimized by strictly composting manure before application to edible crops?
(A) The rapid accumulation of synthetic chemical pesticide residues on crops
(B) Severe crop spoilage and damage arising from heavy metal soil toxicity
(C) Contamination by human pathogens such as E. coli and Salmonella species
(D) The rapid development of synthetic chemical resistance in target insects

2012
47. Which term best describes the natural aging and quality deterioration of organic fruits occurring immediately post-harvest due to continued respiration?
(A) Pathogenic decay process
(B) Anaerobic fermentation
(C) Bacterial putrefaction
(D) Physiological senescence

2009
48. Match the biocontrol agent in List I with its classification in List II:
List I: (Biocontrol Agent)
P. Ladybird beetle
Q. Trichogramma
R. Pseudomonas fluorescens
S. Beauveria bassiana
List II: (Classification)
1. Entomopathogenic fungus
2. Bacterial antagonist
3. Egg parasitoid
4. Generalist predator
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

2022
49. In biodynamic farming, cosmic rhythms are considered vital. This concept primarily dictates that agricultural activities should be timed according to:
(A) The fiscal calendar cycles of the local state

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2009

66. When evaluating the nutritional quality of organic versus conventional produce, studies often cite a lower incidence of which compound in organic vegetables?
(A) Ascorbic acid (Vitamin C)
(B) Dry matter content
(C) Essential amino acids
(D) Nitrates

2006

67. The practice of curing organic tuber crops post-harvest is primarily done to:
(A) Heal surface wounds and thicken the skin to reduce water loss and pathogen entry
(B) Promote rapid biochemical ripening and softening of the internal tuber flesh
(C) Chemically bleach the outer skin layer to achieve a brighter market appearance
(D) Induce immediate physiological sprouting of the tubers for the planting season

2003

68. Match the organic farming standard/system in List I with its primary focus in List II:
List I: (Standard/System)
P. NPOP
Q. PGS-India
R. Jaivik Bharat
S. TraceNet
List II: (Primary Focus)
1. Online traceability software
2. Unified domestic logo
3. Peer-review certification
4. National export standards
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-4, Q-2, R-1, S-3

2011

69. Which of the following is considered a core ethical value driving the global organic agriculture movement?
(A) Ensuring animal welfare by allowing natural behaviors and living conditions
(B) Maximizing immediate monetary farm yield regardless of long-term ecological cost
(C) Prioritizing the patenting and corporate monopolization of indigenous seed varieties
(D) Encouraging the vertical integration of smallholder farms into large corporate entities

2004

70. The application of biodynamic preparation BD-501 (horn silica) is primarily intended to:
(A) Substantially increase the rate of soil humus formation
(B) Rapidly cure systemic fungal infections in the root zone
(C) Act as a highly concentrated nitrogenous organic fertilizer
(D) Enhance light metabolism, photosynthesis, and crop quality

2006

71. How is Organic Nutrient Use Efficiency (ONUE) typically improved in an organic farming system?
(A) By applying massive, single doses of raw, undecomposed livestock manure at sowing
(B) By utilizing slow-release composts synchronized with critical crop growth stages
(C) By switching entirely to foliar nutritional sprays and abandoning soil management
(D) By completely withholding organic matter inputs to force deeper root systems growth

2004

72. Consider the following statements regarding organic land conversion:
I. Simultaneous production of organic and conventional crops on the same field is strictly permitted.
II. Clear physical boundaries must exist between organic and conventional plots on a split farm.
III. The certification body can retroactively recognize conversion periods under exceptional circumstances.
Which of the above statements is/are INCORRECT?
(A) I
(B) I and III
(C) II and III
(D) II

NODIA

2023

73. Which type of multiple cropping system is defined as growing two or more crops simultaneously on the same piece of land without a distinct row arrangement?
(A) Intercropping
(B) Relay cropping
(C) Sequential cropping
(D) Mixed cropping

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2017
25. The socio-economic impact of organic farming on smallholder livelihoods typically includes all the following EXCEPT:
(A) Reduced reliance on expensive external synthetic inputs
(B) Potential access to premium markets and higher product prices
(C) Enhanced utilization of local labor and traditional knowledge
(D) Increased vulnerability to global chemical price fluctuations

2002
26. Which of the following metrics is most relevant for assessing the agronomic nutrient use efficiency of an applied organic manure?
(A) The ratio of crop yield increase to nutrient applied
(B) The total dry weed biomass generated per hectare of land
(C) The total volume of irrigation water applied to the crop
(D) The physical density of the harvested agricultural grain

2006
27. The historical foundation of modern organic agriculture in the early 20th century is closely associated with the work of which pioneer?
(A) Norman Borlaug
(B) Sir Albert Howard
(C) Justus von Liebig
(D) Fritz Haber

2007
28. Match the biodynamic preparation in List I with its core constituent material in List II:
List I: (Biodynamic Preparation)
P. BD 501
Q. BD 502
R. BD 503
S. BD 504
List II: (Core Constituent Material)
1. Yarrow blossoms
2. Chamomile blossoms
3. Horn silica
4. Stinging nettle

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

2010
29. Which principle emphasizes that organic agriculture should be managed in a precautionary and responsible manner to protect current and future generations?
(A) Principle of Care
(B) Principle of Health
(C) Principle of Ecology
(D) Principle of Fairness

2014
30. Which organic certification logo is jointly launched by FSSAI, APEDA, and PGS-India for unified domestic organic product recognition?
(A) India Organic
(B) Agmark
(C) Jaivik Bharat
(D) EcoMark

2013
31. Identify the INCORRECT statement regarding the conversion period in organic farming.
(A) It is the time required for a conventional farm to attain full organic status.
(B) The conversion period for annual crops is typically 24 months before the sowing of the organic crop.
(C) Perennial plants generally require a 36-month conversion period prior to the first organic harvest.
(D) Produce harvested during this period can be sold with the standard "certified organic" label.

2017
32. Consider the following statements regarding green manuring practices:
I. In-situ green manuring involves growing a crop and incorporating it into the same field.
II. Ex-situ green leaf manuring involves bringing foliage from outside sources to incorporate into the field.
III. Green manure crops typically possess high carbon-to-nitrogen ($C{:}N$) ratios, exceeding 80:1.
IV. Sesbania aculeata is a widely utilized leguminous green manure crop.
Which of the above statements is/are INCORRECT?
(A) I and II

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between crop rows
(D) Utilizing flame weeders to rapidly scorch emerged seedlings

2023
82. Rotenone, a naturally occurring botanical insecticide, exerts its toxic effect on pests primarily by:
(A) Digesting the chitin in the insect exoskeleton
(B) Preventing the moulding process by mimicking juvenile hormones
(C) Causing rapid desiccation of the insect cuticle
(D) Inhibiting cellular respiration in the mitochondria

2015
83. The entomopathogenic fungus Beauveria bassiana causes which specific disease in targeted insect pests?
(A) White muscardine disease
(B) Green muscardine disease
(C) Milky spore disease
(D) Late blight

2014
84. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Organically grown fruits often have a slightly shorter shelf life than conventionally grown fruits if post-harvest chemical treatments are not substituted with effective physical management.
Reason (R): Organic standards prohibit the use of synthetic fungicides and artificial wax coatings commonly used to delay post-harvest decay.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2025
85. What is the fundamental requirement for an organic food product to be legally exported from India to countries like the EU or USA?
(A) It must be certified by an APEDA-accredited certification body under NPOP standards.
(B) It must bear only the local PGS-India green certification label on its outer packaging.
(C) It must be inspected visually by port customs officials without any paper documentation.
(D) It must originate from an agricultural holding larger than 100 total contiguous hectares.

2017
86. In the context of the PGS-India certification system, the basic structural unit responsible for monitoring is the:
(A) Regional Council appointed by the State Government
(B) Individual farmer acting in total isolation
(C) Multi-national auditing corporation
(D) Local Group (LG) of at least 5 interacting farmers

2007
87. Under NPOP labeling regulations, a product can be labeled as "Produce of Organic Agriculture" only if:
(A) At least 50% of its ingredients are of certified organic origin.
(B) No less than 95% of its ingredients are of certified organic origin.
(C) It contains absolutely no water or salt.
(D) It is packaged in 100% biodegradable materials, regardless of ingredient origin.

2018
88. Match the biodynamic preparation number in List I with its specific usage in List II:
List I: (Biodynamic Preparation Number)
P. BD 500
Q. BD 501
R. BD 505
S. BD 508
List II: (Specific Usage)
1. Fungal control (Equisetum arvense)
2. Soil application for root growth
3. Compost additive (Oak bark)
4. Foliar application for photosynthesis
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-3, R-2, S-4

2019
89. Which of the following best infers the socio-economic benefit of utilizing ITK (Indigenous Technical Knowledge) formulations in organic farming?
(A) It forces farmers to purchase expensive imported raw materials.
(B) It necessitates advanced machinery, boosting rural industrialization.
(C) It heavily relies on complex laboratory synthesis, raising the technical skill baseline.
(D) It promotes self-reliance by utilizing locally

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available, low-cost farm resources.

2022

90. Which factor most significantly limits the wide-scale adoption of purely organic farming across massive conventional monoculture regions?
(A) The initial transition phase marked by yield dips and high labor demand
(B) The complete absence of consumer demand for certified organic products.
(C) The lack of any theoretical knowledge needed to manage organic systems.
(D) The international trade prohibition of organic products under global laws.

2019

91. The concept of "food miles" is often discussed in ecological farming. Which practice best minimizes food miles?
(A) Exporting organic fresh produce using high-speed international air freight logistics
(B) Establishing robust local supply chains and community-supported agriculture (CSA) systems
(C) Centralizing all organic agricultural processing within one massive national facility
(D) Importing off-season organic fruits globally to maintain continuous year-round availability

2004

92. Consider the following statements regarding the differences between organic and conventional farming:
I. Organic farming relies on crop rotation for pest management, while conventional heavily uses synthetic pesticides.
II. Conventional farming primarily utilizes water-soluble chemical fertilizers for instant nutrient availability.
III. Organic farming strictly prohibits the use of mechanical tillage.
IV. Both systems legally permit the cultivation of genetically modified (GM) crops.
Which of the above statements are correct?
(A) I and II
(B) I, II and III
(C) II and IV
(D) I and IV

2009

93. According to IFOAM, the Principle of Ecology implies that organic farming should be based on:
(A) Living ecological systems, working with them, emulating them, and helping sustain them
(B) Artificial high-tech hydroponic growing systems completely isolated from soil ecosystems
(C) Rapid exploitation of ecological niches to yield maximum short-term agricultural output
(D) The systematic eradication of all non-crop flora and fauna from the farm environment

2015

94. Which Indian state is officially recognized as the world's first fully organic state?
(A) Madhya Pradesh
(B) Maharashtra
(C) Sikkim
(D) Kerala

2006

95. If a farm is transitioning from conventional to organic status, what determines the start date of the conversion period?
(A) The date the farmer verbally decides to halt synthetic chemical inputs
(B) The date the final conventionally grown crop is sold in the market
(C) The date the first batch of organic seeds is purchased and registered
(D) The date of the first inspection by the accredited certification body

2017

96. Which cropping strategy is specifically designed to provide a continuous, varied supply of forage for livestock in an integrated system?
(A) Monoculture cash cropping
(B) Intensive relay cropping of cereal grains
(C) Mixed cropping of grasses and legumes
(D) Continuous fallowing

NODIA

2004

97. In an Integrated Organic Farming System, the inclusion of aquaculture (fish farming) alongside paddy cultivation provides which of the following ecological services?
(A) The fish completely eliminate any seasonal requirement for external irrigation water input.
(B) Fish excreta provides nutrients, while their swimming movement aerates water and controls weeds.
(C) The fish selectively feed on the main paddy tillers, pruning the rice plant for better growth.
(D) The fish act to significantly lower the local

microclimatic canopy temperature of the rice.

2013

98. Which biological soil health parameter represents the fraction of soil organic matter that is readily available as a food source for microorganisms?
(A) Recalcitrant carbon compounds
(B) Highly stable humic acid fraction
(C) Total mineral soil ash residue
(D) Active or labile carbon fraction

2021

99. The ideal Carbon to Nitrogen ($C{:}N$) ratio for rapid and efficient composting of organic residues is approximately:
(A) 1:1 to 5:1
(B) 10:1 to 15:1
(C) 25:1 to 30:1
(D) 80:1 to 100:1

2007

100. Which concentrated organic manure is recognized for possessing both nitrogen-rich nutritional properties and significant nematicidal properties?
(A) Blood meal
(B) Bone meal
(C) Neem cake
(D) Fish meal

2011

101. What is the fundamental agricultural purpose of utilizing VAM (Vesicular Arbuscular Mycorrhizae)?
(A) To form symbioses with roots, expanding surface area for enhanced phosphorus and water uptake
(B) To fix atmospheric nitrogen within the leaf structures of non-legume dryland cereal crops
(C) To rapidly decompose highly lignified wood chips and bark material on the soil surface
(D) To competitively exclude all beneficial plant-promoting bacteria from the rhizosphere

2005

102. In the context of biogas production, how does temperature affect the rate of methanogenesis?
(A) It is entirely independent of any environmental temperature variations on site.
(B) The digestion rate peaks exclusively under freezing temperatures near zero degrees.
(C) It functions efficiently only when the slurry reaches the boiling point of water.
(D) It is optimal in mesophilic or thermophilic ranges, slowing down in cold climates.

2003

103. Which ITK formulation is primarily recommended for foliar application to enhance plant growth and induce resistance against diseases, rather than strictly for soil application?
(A) Bijamrita
(B) Panchagavya
(C) Sanjivani
(D) Amrit Mitti

2006

104. Consider the following statements concerning earthworm ecology in organic farming:
I. Epigeic earthworms are ideal for deep soil mixing and aeration.
II. Anecic earthworms create permanent vertical burrows and pull surface litter down.
III. Endogeic earthworms feed on organic matter deep within the soil profile.
IV. Vermiwash is a liquid extract collected during vermicomposting, rich in enzymes and nutrients.
Which of the above statements are correct?
(A) I, II and III
(B) II, III and IV
(C) I, III and IV
(D) I, II and IV

2009

105. Blind tillage is an effective mechanical weed control method characterized by:
(A) Deep mechanical plowing of soil to a depth of forty-five centimeters prior to sowing
(B) Intensive hand-weeding of agricultural fields carried out exclusively during the night
(C) The use of heavy rollers to crush and destroy mature weed crops in the standing field
(D) Shallow cultivation of the entire field after sowing but before crop seedlings emerge

2017

106. Which active principle, derived from the roots of Derris elliptica, is permitted with restrictions in organic farming as a broad-spectrum insecticide and piscicide?
(A) Azadirachtin
(B) Rotenone
(C) Sabadilla
(D) Ryania

2007

107. The biological control agent Pseudomonas fluorescens manages soil-borne plant pathogens through which primary mechanism?

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(C) The exclusive reliance on global stock markets to dictate crop planting dates
(D) Seed sovereignty, protecting the farmer's right to save and exchange seeds

2003

161. Water Use Efficiency (WUE) in an organic system can be mathematically expressed as:
(A) $WUE = \frac{\text{Crop Yield}}{\text{Evapo transpiration}}$
(B) $WUE = \frac{\text{Evapo transpiration}}{\text{Crop Yield}}$
(C) $WUE = \text{Crop Yield} \times \text{Rain fall}$
(D) $WUE = \frac{\text{Rain fall}}{\text{Deep Percolation}}$

2013

162. Which classification best describes the farming system promoted by Masanobu Fukuoka?
(A) Mechanized organic farming
(B) Precision chemical farming
(C) Natural farming systems
(D) Hydroponic crop farming

2025

163. What is the fundamental reason synthetic herbicides are banned in organic farming systems?
(A) They harm soil biology and contradict ecological principles.
(B) They are too cheap and would disrupt local rural economies.
(C) They evaporate too quickly to be effective on organic soils.
(D) They promote excessive and unbalanced earthworm populations.

2016

164. What is the standard required conversion period for a conventional apple orchard before the harvested fruit can be certified as fully organic?
(A) 12 months
(B) 24 months
(C) 36 months
(D) 60 months

2019

165. The practice of multiple cropping in an organic system is most directly aimed at achieving which of the following?
(A) Maximizing the risk of complete crop failure across agricultural fields
(B) Enhancing biodiversity for better soil resource use and pest buffering
(C) Simplifying harvesting processes by using massive singular machinery
(D) Eliminating the need for any form of active soil nutrient management

2016

166. Which component of an Integrated Organic Farming System acts as the primary "nutrient transformer," converting high-volume, low-nutrient crop residues into high-quality organic manure?
(A) The main cereal crop
(B) The solar water pump
(C) The livestock component
(D) The peripheral boundary fence

2006

167. Soil chemical health under long-term organic management typically exhibits which distinct trend compared to conventional management?
(A) A drastic reduction in the levels of total soil organic carbon
(B) A steady decline in soil pH values towards extreme soil acidity
(C) Rapid accumulation of toxic heavy metal residues in the topsoil
(D) Improved cation exchange capacity and steady nitrogen release

2021

168. During the preparation of compost, the C:N ratio is critical. Which material is typically added to supply 'Carbon' (browns)?
(A) Dry straw or sawdust
(B) Fresh poultry manure
(C) Green legume leaves
(D) Fresh cow urine

NODIA

2023

169. What is the correct sequence of phases during the composting process?
(A) Maturation → Thermophilic → Mesophilic
(B) Mesophilic → Thermophilic → Maturation
(C) Thermophilic → Maturation → Mesophilic
(D) Cooling → Mesophilic → Thermophilic

2004

170. Which green manure crop is uniquely tolerant to waterlogged and alkaline soil conditions, making it ideal for reclamation and organic paddy systems?
(A) Crotalaria juncea (Sunnhemp)
(B) Sesbania aculeata (Dhaincha)
(C) Vigna radiata (Mungbean)
(D) Cyamopsis tetragonoloba (Guar)

2011

115. Which index represents the efficiency with which a crop converts physical water transpired into harvestable biomass in an organic system?
(A) Transpiration Efficiency
(B) Economic Water Use Efficiency
(C) Consumptive Use Efficiency
(D) Irrigation Efficiency

2022

116. Identify the correct pair representing a fundamental concept and its matching definition.
(A) Permaculture : An agricultural system focused solely on growing annual monoculture crop species
(B) Hydroponics : The cultivation of food crops in highly organic, compost-rich field soil mixtures
(C) Precision farming : Agricultural production utilizing exclusively traditional hand-held wooden tools
(D) Biodynamic farming : Agriculture utilizing specific fermented preparations and cosmic rhythms

2003

117. Identify the INCORRECT statement regarding the differences between natural farming and organic farming.
(A) Organic farming permits the use of standard bulky organic manures like compost.
(B) Both systems rely on complex synthetic herbicide rotations.
(C) Natural farming (e.g., Do-Nothing farming) heavily emphasizes zero external inputs and zero tillage.
(D) Organic farming involves regular soil interventions like ploughing and weeding, unlike strict natural farming.

2025

118. Which of the following statements regarding organic certification standards for seeds is INCORRECT?
(A) Seeds must be organically produced.
(B) Seeds must not be genetically modified (non-GMO).
(C) Seeds treated with synthetic fungicides are acceptable if washed thoroughly before planting.
(D) If certified organic seeds are totally unavailable, chemically untreated conventional seeds may be used with permission.

2008

119. Which of the following best describes a "parallel production" scenario in organic certification standards?
(A) Growing wheat in one row and mustard in adjacent rows under an organic system
(B) Two neighboring organic farmers growing completely different certified crops
(C) Producing both liquid bio-formulations and solid organic manures simultaneously
(D) Growing the same crop variety organically and conventionally on the same holding

2008

120. Crop rotation in organic systems mitigates soil-borne diseases primarily through which mechanism?
(A) By breaking pathogen life cycles through the introduction of non-host crop species
(B) By completely and permanently sterilizing the native microbial community in the soil
(C) By raising soil temperatures to lethal levels during high solar radiation phases
(D) By physically crushing dormant fungal spores through repeated crop root expansion

2013

121. What is the defining characteristic of a "catch crop" utilized in organic cropping systems?
(A) A crop species grown primarily to attract, catch, and trap insect pests in the field
(B) A fast-growing crop grown between main crops to utilize nutrients and prevent leaching
(C) A heavily armed, thorny border crop grown to catch and deter trespassing wild animals
(D) A highly aromatic crop grown solely to capture the attention of beneficial pollinators

2012

122. In an Integrated Organic Farming System, what is the specific role of planting multipurpose tree species (MPTS) on the field bunds?
(A) To maximize wind speed across the open soil surface
(B) To provide fodder, fuel, green manure, and windbreaks
(C) To permanently shade out the growing main food crops
(D) To attract large flocks of crop pest birds to the farm

2019

123. The physical indicator of soil health known as "aggregate stability" is crucial in organic farming because it directly correlates with:

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(A) The soil's capacity to resist erosion and maintain porosity under rain impact
(B) The exact percentage of plant-available elemental nitrogen in the topsoil layer
(C) The development of a highly uniform and distinct color in the subsoil horizon
(D) The physical measurement of the specific heat capacity of underlying bedrock

2006

124. Consider the following statements regarding bulky organic manures:
I. They supply large amounts of organic matter, which improves soil physical properties.
II. Their macro-nutrient content (N, P, K) is typically very high, usually exceeding 15% nitrogen by weight.
III. They enhance the water-holding capacity of sandy soils.
IV. Farmyard manure is a classic example of a bulky organic manure.
Which of the above statements are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I and II

2022

125. The process of green manuring in-situ ideally involves incorporating the crop into the soil at which specific growth stage for optimal nitrogen release?
(A) Just after seed germination
(B) Fully mature, when pods are dry and stems are highly lignified
(C) After natural senescence and complete leaf fall
(D) At the active flowering stage, before they become overly woody

2007

126. Which group of microorganisms is responsible for the non-symbiotic (free-living) fixation of nitrogen in aerobic soil conditions?
(A) Rhizobium species
(B) Nitrobacter species
(C) Azotobacter species
(D) Frankia species

2005

127. What is the fundamental distinction between biogas slurry and raw animal dung when applied to an organic field?
(A) The processed slurry is completely free of all odors and is entirely sterile.
(B) The slurry features a narrower C:N ratio and more available ammoniacal nitrogen.
(C) The raw dung decomposes almost instantly, while slurry takes years to decay.
(D) The slurry is characterized by containing absolutely no phosphorus or potassium.

2005

128. What is the primary function of utilizing undisturbed forest soil in the preparation of Jeevamrutha?
(A) To provide substantial physical bulk to the final liquid mixture
(B) To increase mechanical abrasiveness of the liquid spray on weeds
(C) To naturally dye the resulting solution a dark, aesthetic color
(D) To introduce a diverse inoculum of indigenous beneficial microbes

2002

129. During vermicomposting, the transformation of organic waste into casts results in a product with a highly reduced:
(A) Pathogen and weed seed load
(B) Cation exchange capacity
(C) Total humic acid content
(D) Available nitrogen content

2023

130. A farmer employs a strategy of increasing the seeding rate of an organic wheat crop by 15% above the conventional recommendation. What is the most likely agronomic reason for this?
(A) To exhaust soil moisture and induce early crop drought stress
(B) To increase the individual grain weight and size of wheat
(C) To suppress weeds through earlier crop canopy competition
(D) To legally qualify for direct organic seed subsidy programs

NODIA

2011

131. Which of the following botanical extracts acts specifically as an insect growth regulator (IGR) and antifeedant, rather than a rapid contact poison?
(A) Neem seed kernel extract
(B) Natural pyrethrum liquid
(C) Soluble nicotine sulfate
(D) Rotenone root extract

2006

132. The release of Trichogramma chilonis in an organic sugarcane field is a classical example of:

(A) Agronomic weed management
(B) Botanical disease suppression
(C) Mechanical pest eradication
(D) Inundative biological control

2016
133. When evaluating the food safety of organic produce, what potential risk is associated with the improper, incomplete composting of animal manures?
(A) Increased persistence of synthetic herbicide residues
(B) Transmission of enteric pathogens to raw vegetables
(C) Heavy metal accumulation inside the edible plant tissue
(D) Extreme depletion of essential vitamins in the crops

2018
134. Pre-cooling of freshly harvested organic vegetables is critical primarily because it:
(A) Instantly freezes tissue, preventing all internal cellular activity
(B) Chemically strengthens cell walls to prevent mechanical bruising
(C) Removes field heat, slowing respiration and delaying senescence
(D) Washes off natural protective waxes from the harvested fruit surface

2008
135. Under the institutional framework for Indian organic agriculture, which organization is responsible for setting the standards for NPOP?
(A) Ministry of New and Renewable Energy
(B) Ministry of Earth Sciences
(C) Ministry of Rural Development
(D) Ministry of Commerce and Industry

2002
136. Consider the following statements regarding third-party organic certification:
I. It requires meticulous documentation of all farm inputs and practices.
II. It is generally inexpensive and perfectly suited for individual marginal farmers.
III. It involves annual inspections by a formally accredited agency.
IV. It facilitates access to regulated international export markets.
V. Non-compliances can lead to the immediate revocation of the organic certificate.
Which of the above statements is/are INCORRECT?
(A) II
(B) I and III
(C) II, III and V
(D) IV and V

2023
137. Which unique identification mechanism is generated by the TraceNet system to ensure the traceability of an exported organic consignment?
(A) A localized, handwritten receipt issued by the farmer
(B) A lot number linked to a digital Transaction Certificate
(C) A generic barcode used across all agricultural commodities
(D) A physical metal identification tag attached to each fruit

2004
138. Which biodynamic preparation is uniquely prepared by stuffing cow manure into a cow horn and burying it in the soil over the winter months?
(A) BD 500
(B) BD 501
(C) BD 502
(D) BD 508

2006
139. A fundamental tenet of the spiritual and ethical dimension of organic agriculture is 'Ahinsa' (non-violence). How is this practically translated into farm management?
(A) Using biological control and natural processes instead of chemical annihilation
(B) Complete abandonment of all tillage and mechanical weeding practices on fields
(C) The total, strict prohibition of rearing any livestock or animals on the farm
(D) Refusing to harvest or collect seeds from any agricultural crop grown in fields

2005
140. Which factor is most critical in maximizing Organic Nutrient Use Efficiency (ONUE) in sandy soils?
(A) Applying a single massive dose of liquid slurry during the monsoons
(B) Leaving the soil completely bare and unprotected between crop seasons
(C) Frequent, small applications of compost to build structural retention
(D) Deep plowing the soil to expose organic nutrients to intense sunlight

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2014

141. The initial phase of transitioning to organic agriculture requires defining the baseline status of the farm. Which document is central to this process under formal certification?
(A) The daily weather logbook
(B) The national agricultural census
(C) The local taxation registry
(D) The Organic System Plan (OSP)

2011

142. Which crop rotation sequence is agronomically most rational for maintaining nitrogen balance in an organic farming system?
(A) Maize - Sorghum - Pearl Millet
(B) Cotton - Sunflower - Castor
(C) Rice - Chickpea - Mungbean
(D) Sugarcane - Wheat - Barley

2008

143. In an Integrated Organic Farming System (IOFS) involving dairy, crop, and forestry components, what is the primary role of the forestry component?
(A) To generate structural timber for immediate cash and export markets
(B) To act as a nutrient sink, windbreak, and source of mulching material
(C) To eradicate all understory grasses and weed species beneath the trees
(D) To completely shade food crops, lowering topsoil temperatures to zero

2019

144. Soil biological health is often quantified by measuring the "soil respiration" rate. What exactly does this measure?
(A) The physical displacement of soil air by water during intense rainfall
(B) The total amount of oxygen released by growing plant roots into the soil
(C) The chemical intake of gaseous atmospheric nitrogen by soil-dwelling fungi
(D) The volume of carbon dioxide released by soil microbial and root activity

2012

145. What happens to the composting process if the Carbon to Nitrogen (C:N) ratio of the initial feedstock is too low (e.g., 10:1)?
(A) Nitrogen is lost as volatile ammonia gas, causing a foul odor.
(B) The pile fails to heat up due to a lack of available nitrogen.
(C) Excess carbon causes the composting pile to instantly fossilize.
(D) The biochemical decomposition process will stop completely.

2004

146. Which of the following organic manures is derived from the residues of the oil extraction industry and is notable for its slow release of nitrogen?
(A) Vermicompost
(B) Biogas slurry
(C) Castor cake
(D) Poultry manure

2001

147. Which biofertilizer utilizes an endophytic relationship to fix nitrogen within the stems and roots of sugarcane?
(A) Gluconacetobacter diazotrophicus
(B) Bacillus megaterium
(C) Trichoderma harzianum
(D) Rhizobium leguminosarum

2017

148. During the acetogenesis phase of biogas production, what is the primary chemical transformation that occurs?
(A) Conversion of complex carbohydrates and plant polymers into simple sugars
(B) Conversion of dissolved acetic acid directly into gaseous pure methane
(C) Conversion of gaseous atmospheric nitrogen into plant-available ammonia
(D) Conversion of simple organic acids and alcohols into acetic acid and hydrogen

NODIA

2003

149. Panchagavya has been documented to contain various beneficial plant growth promoters. Which specific hormones are commonly reported to be present in this formulation?
(A) Synthetic auxins such as 2,4-D compounds
(B) Indole Acetic Acid and Gibberellic Acid
(C) Highly concentrated ethylene gas compounds
(D) Naturally occurring abscisic acid only

2019

150. Earthworm casts are prized in organic agriculture because, compared to the surrounding bulk soil, they typically exhibit:
(A) A dramatically lower pH value, turning soil highly acidic
(B) Absolute microbial sterility and total lack of organic carbon
(C) Higher levels of plant-available nutrients and microbial counts
(D) Extreme structural compaction, leading to hardpan formation

2025

151. Which weed management technique is most appropriately classified as an "ecological" or "habitat management" strategy?
(A) Regular application of highly concentrated chemical salt solutions to the soil
(B) Using heavy, fuel-powered tractor-mounted mechanical cultivators in fields
(C) Uprooting weeds entirely by hand with manual labor during early crop growth
(D) Manipulating crop spacing, varieties, and sowing dates to outcompete weeds

2005

152. Which botanical extract is historically recognized for its distinct active principle, "azadirachtin", which disrupts insect moulting?
(A) Neem
(B) Chrysanthemum
(C) Tobacco
(D) Garlic

2013

153. What is the fundamental mode of action of Bacillus thuringiensis (Bt) when applied as a microbial biopesticide in organic farming?
(A) It acts as an active parasite that destroys eggs of target insect pests in fields.
(B) It must be ingested to let its protein crystals rupture the caterpillar midgut.
(C) It acts as a contact chemical poison that rapidly corrodes the insect exoskeleton.
(D) It acts as a powerful repellent, preventing flying insects from landing on crops.

2017

154. An advantage of organically produced milk, according to some comparative biochemical studies, is a higher concentration of which specific fatty acid?
(A) Trans-palmitoleic acid
(B) Conjugated Linoleic Acid
(C) Synthetic saturated lipids
(D) Hydrogenated trans fats

2018

155. Which natural treatment is permitted in organic agriculture to control post-harvest fungal decay in certain fruits?
(A) Use of hot water treatments or plant essential oil coatings
(B) Application of synthetic benomyl chemical fungicide dips
(C) Submerging the fruit in concentrated chlorine bleach solutions
(D) Direct exposure of harvested produce to radioactive gamma rays

NODIA

2003

156. The Agricultural and Processed Food Products Export Development Authority (APEDA) operates under which Ministry of the Government of India?
(A) Ministry of Agriculture & Farmers Welfare
(B) Ministry of Food Processing Industries
(C) Ministry of Commerce and Industry
(D) Ministry of Environment, Forest and Climate Change

2016

157. In the context of PGS-India, what happens if an individual farmer within a Local Group defaults on organic standards?
(A) Only that specific farmer is fined, and the rest of the group continues unaffected.
(B) The defaulting farmer is simply transferred to a completely different Local Group.
(C) The government compensates the defaulting farmer for any resulting crop losses.
(D) The entire Local Group risks losing certification due to collective responsibility.

2012

158. The Jaivik Bharat logo visually incorporates a specific leaf element. This logo is mandatory for which category of organic products?
(A) Organic textiles and garments for domestic sale
(B) Only raw agricultural commodities meant for export
(C) Certified organic food products sold within India
(D) Organic fertilizers and bulk manure formulations

2006

159. In biodynamic agriculture, preparation BD 504 is derived from which plant, known for its high iron content and role in stabilizing nitrogen?
(A) Yarrow (Achillea millefolium)
(B) Stinging Nettle (Urtica dioica)
(C) Chamomile (Matricaria recutita)
(D) Dandelion (Taraxacum officinale)

2015

160. Which concept directly connects the spiritual values of organic farming with socio-economic empowerment?
(A) The patenting of genetically modified crop seeds to generate corporate wealth
(B) The total automation of agricultural farming systems to replace human labor

2002

181. In the step-by-step process of organic certification, an "NC" issued by an inspector stands for:
(A) Natural Compost
(B) Non-Compliance
(C) National Certification
(D) Nutrient Cycle

2010

182. A farmer wishes to use the Jaivik Bharat logo on a processed food product. Which regulatory body's standards must this product fundamentally comply with?
(A) Bureau of Indian Standards (BIS) organization
(B) Indian Medical Association (IMA) organization
(C) Food Safety and Standards Authority of India
(D) Central Pollution Control Board (CPCB) agency

2010

183. Which biodynamic preparation is famously made by packing yarrow flowers into a stag's bladder and exposing it to the summer sun and winter burial?
(A) BD 501
(B) BD 502
(C) BD 503
(D) BD 504

2018

184. The ethical framework of organic farming promotes "fairness". In the context of agricultural labor, this means:
(A) Providing living wages, safe conditions, and workers' rights
(B) Replacing all human farm labor with robotic automation systems
(C) Forcing field laborers to accept crop produce instead of cash
(D) Employing cheap, undocumented labor to keep food prices low

2021

185. Agronomic Nutrient Use Efficiency is often lower in organic systems during the initial transition phase primarily because:
(A) Applied organic fertilizers instantly volatilize upon direct contact with open air
(B) Nutrients are bound in complex organic molecules requiring microbial mineralization
(C) Conventional crop varieties are totally incapable of absorbing organic nitrogen forms
(D) Organic systems use absolutely zero external water, stopping all nutrient flows

2003

186. Which IFOAM principle dictates that organic agriculture should be based on risk assessment and the adoption of appropriate technologies that avoid unpredictable consequences?
(A) Principle of Health
(B) Principle of Care
(C) Principle of Ecology
(D) Principle of Fairness

2003

187. In the context of global organic agriculture statistics, which country possesses the largest total area of certified organic agricultural land?
(A) Australia
(B) India
(C) United States of America
(D) China

2009

188. Which of the following defines a "split production" system in the context of organic certification?
(A) A farming area that is completely divided into two parts by a natural river
(B) Splitting the crop harvest equally between domestic sales and export markets
(C) Producing organic and conventional crops of different varieties on one farm
(D) Cultivating agricultural crops for only half of the standard calendar year

2002

189. Which cropping system utilizes the space between rows of the main crop to grow a subordinate crop, heavily utilized in organic systems for weed suppression and soil conservation?
(A) Ratoon cropping
(B) Sole cropping
(C) Fallow cropping
(D) Intercropping

2005

190. What is a primary challenge in managing an Integrated Organic Farming System (IOFS)?
(A) It requires absolutely no manual labor or effort from the farming family.
(B) It necessitates constant, expensive purchase of synthetic chemical inputs.
(C) It requires complex management to synchronize diverse components and flows.
(D) It completely and permanently isolates the farmer from the local ecosystem.

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2005
171. Which biofertilizer is typically used for mobilizing phosphorus in organic farming via a symbiotic relationship with plant roots?
(A) Mycorrhiza (AMF)
(B) Azospirillum
(C) Rhizobium
(D) Nitrobacter

2019
172. The calorific value of biogas is primarily determined by the concentration of which specific gas in the mixture?
(A) Carbon dioxide
(B) Hydrogen sulfide
(C) Methane
(D) Nitrogen

2025
173. Which indigenous formulation requires a fermentation period of 48 to 72 hours and is known to dramatically stimulate soil microbial activity upon application?
(A) Beejamrutha
(B) Neem oil
(C) Wood ash solution
(D) Jeevamrutha

2009
174. Which process represents the crucial contribution of earthworms to the soil structural health in organic farming?
(A) Destruction of structural soil aggregates
(B) Depletion of total plant-available soil porosity
(C) Formation of water-stable soil macro-aggregates
(D) Creation of highly impenetrable subsoil hardpans

2023
175. Mulching is widely practiced in organic weed management. What is its primary physical mechanism of action?
(A) It releases synthetic chemicals that inhibit seed germination.
(B) It physically deprives emerging weed seedlings of light.
(C) It freezes the soil surface, rapidly killing weed roots.
(D) It actively attracts weed-eating bird species to fields.

2003
176. Which botanical pesticide is most effectively used against soft-bodied insects like aphids and is formulated from the seeds of the Pongam tree?
(A) Azadirachtin
(B) Nicotine
(C) Pyrethrin
(D) Karanjin

2017
177. NPV (Nuclear Polyhedrosis Virus) formulations must be sprayed during the late evening hours in organic farming primarily because:
(A) Viral particles are highly sensitive to degradation by ultraviolet (UV) sunlight.
(B) The virus is strictly nocturnal and remains completely inactive during the day.`
(C) Target pest caterpillars only emerge from soil during periods of heavy rainfall.
(D) Stomata of the crop plants are closed at night, preventing viral leaf entry.

NODIA

2008
178. Which statement represents a well-documented advantage of organic farming regarding food quality?
(A) Organic crops consistently have double the protein content of conventional ones.
(B) Organic produce is completely immune to all forms of bacterial crop spoilage.
(C) Organic produce has lower incidence of detectable synthetic pesticide residues.
(D) Organic farming completely removes natural heavy metals from agricultural soil.

2025
179. To minimize pathological losses during the storage of organic potatoes, which condition must be strictly avoided?
(A) High humidity combined with poor ventilation
(B) Proper curing before storage
(C) Storage at cool temperatures (4-10°C)
(D) Removal of damaged and diseased tubers before storage

2012
180. The NPOP standard dictates that the use of genetically engineered organisms or their products in organic farming is:
(A) Permitted for non-edible crop varieties only
(B) Allowed if the GM trait is for drought tolerance
(C) Permitted during conversion but banned thereafter
(D) Strictly prohibited at all production stages

(A) By producing iron-sequestering siderophores to starve pathogens
(B) By physically strangulating and wrapping around fungal hyphae
(C) By fixing large amounts of nitrogen to chemically burn pathogens
(D) By releasing highly elevated amounts of lethal thermal energy

2015
108. When verifying the authenticity of organically labeled food, which biochemical marker is sometimes analyzed to distinguish it from conventionally grown food?
(A) The concentration of residues from added synthetic food coloring
(B) The total percentage of cellular water within the plant tissue
(C) The stable nitrogen isotope ratio ($\frac{^{15}N}{^{14}N}$) in the crop tissue
(D) The precise geometric shape and structure of the starch granules

2008
109. What is a recommended physical method for controlling storage insect pests in organic grain storage?
(A) Chemical fumigation of storage bins with methyl bromide gas
(B) Admixture of raw grain with synthetic malathion chemical dust
(C) Continuous spraying of storage structures with ammonia solution
(D) Hermetic storage utilizing sealed bags to deplete oxygen levels

2018
110. Which official entity issues the transaction certificate (TC) essential for the export of a specific consignment of organic produce under NPOP?
(A) The local village panchayat
(B) The individual farmer who grew the produce
(C) The accredited certification body that certified the project
(D) The consumer purchasing the produce in the destination country

2006
111. The Participatory Guarantee System (PGS) is best suited for which demographic of farmers?
(A) Massive corporate agro-industrial conglomerates
(B) Small and marginal farmers focused on local and domestic markets
(C) Farmers exclusively cultivating non-food industrial crops
(D) Hydroponic farmers operating in entirely controlled indoor environments

2006
112. Consider the following statements regarding the Jaivik Bharat logo:
I. It is legally mandated for all certified organic food products sold in India.
II. It guarantees the product is sourced exclusively from wild forest harvesting.
III. It signifies compliance with FSSAI organic food regulations.
Which of the above statements are correct?
(A) I
(B) II and III
(C) II
(D) I and III

2003
113. In biodynamic farming, what is the significance of the "descending moon" phase?
(A) It is believed to draw vital forces down into the soil to promote root growth and development.
(B) It is considered the optimal phase for harvesting and storing fruits for long-term preservation.
(C) It dictates the absolute cessation of all manual weeding and sowing activities for two weeks.
(D) It is the only period when specific approved organic soil mineral fertilizers can be applied.

2012
114. The transition from conventional to organic agriculture often leads to an initial decrease in net profitability. What is the most common cause of this?
(A) An instantaneous reduction in available skilled farm labor and management personnel in the area
(B) The extremely high and prohibitive cost of purchasing certified organic or indigenous seeds
(C) Yield decline due to sudden chemical withdrawal before organic price premiums can be realized
(D) The rapid and immediate destruction of beneficial soil microbiomes upon stopping chemical use

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2022
191. Soil biological activity in an organic farm is often assessed by measuring the activity of which critical enzyme, responsible for breaking down urea?
(A) Cellulase
(B) Urease
(C) Dehydrogenase
(D) Phosphatase

2005
192. Which bulky organic manure is produced by anaerobically digesting plant and animal wastes, yielding both combustible gas and a nutrient-rich agricultural residue?
(A) Rural compost
(B) Vermicompost
(C) Night soil
(D) Biogas slurry

2013
193. The application of concentrated oil cakes to organic soil provides nutrients, but it also has a secondary physical effect on the soil. What is it?
(A) It improves soil crumb structure and moisture retention.
(B) It increases topsoil bulk density to hard concrete levels.
(C) It turns soil completely hydrophobic, repelling all water.
(D) It permanently sterilizes the active native soil microbiome.

2017
194. Which of the following biofertilizers is correctly classified as an Actinomycete capable of forming nitrogen-fixing root nodules in non-leguminous plants like Casuarina?
(A) Rhizobium
(B) Azotobacter
(C) Frankia
(D) Azospirillum

2012
195. In the operation of a standard floating-drum biogas plant, which factor must be strictly maintained to ensure uninterrupted methanogenesis?
(A) The absolute exclusion of oxygen
(B) Continuous exposure to open flames
(C) A highly acidic environment ($pH < 3$)
(D) The use of woody branches as feed

2012
196. The preparation of Beejamrutha utilizes cow urine. What specific functional property does cow urine impart to this seed treatment?
(A) It acts as a highly powerful and toxic synthetic herbicide on weeds.
(B) It radically and permanently alters genetic structure of seed embryos.
(C) It physically hardens the seed coat to completely prevent germination.
(D) It provides antimicrobial action protecting seeds from soil pathogens.

2014
197. Which specific group of soil biota is known as the "ecosystem engineers" due to their profound impact on soil structure, porosity, and organic matter incorporation?
(A) Nematodes
(B) Earthworms
(C) Protozoa
(D) Collembola (Springtails)

2016
198. Which of the following represents an agronomic approach to weed management rather than a mechanical one?
(A) Manual hand pulling of weeds in fields
(B) Tractor-drawn mechanical inter-cultivation
(C) High-density planting to outcompete weeds
(D) Flaming the topsoil surface using heat

2004
199. Neem (Azadirachta indica) derivatives are widely used in organic pest control. Which statement accurately describes their primary environmental attribute?
(A) They are highly persistent in the environment and bioaccumulate in apex predators.
(B) They are broad-spectrum and instantly lethal to all beneficial pollinators.
(C) They permanently contaminate groundwater reserves.
(D) They are relatively non-toxic to mammals and degrade rapidly under UV light.

NODIA

2023
200. The predator Chrysoperla carnea (Green lacewing) is highly valued in biological control programs primarily for managing which group of pests?
(A) Soft-bodied insects like aphids
(B) Destructive large rodent pests
(C) Deep-boring crop stem weevils
(D) Soil-dwelling root nematodes

culminating in the final harvesting and sieving of stabilized compost.

37. (A) FYM provides bulky organic matter, while oil cakes act primarily as concentrated nutrients. Farmyard manure is a classic bulky organic manure that provides significant quantities of organic matter to improve soil physical structure, water-holding capacity, and microbial habitats, despite its lower nutrient concentrations. Conversely, concentrated organic manures like oil cakes contain a higher concentration of key nutrients but do not add substantial bulk to the physical soil matrix.

38. (D) Rice
The symbiotic association between the aquatic water fern Azolla and the nitrogen-fixing cyanobacterium Anabaena azollae is widely exploited in flooded paddy rice cultivation. Azolla floats on the water surface, shading out weeds, while the cyanobacterium fixes atmospheric nitrogen directly. When incorporated into the soil, Azolla decomposes rapidly, releasing valuable nitrogen to the growing rice crop.

39. (B) Azospirillum : Obligate symbiotic nodulation in maize
Azospirillum is a free-living, associative diazotrophic bacterium that colonizes the rhizosphere and root surfaces of cereal crops, including maize, millets, and wheat, without establishing obligate nodular symbioses. It fixes atmospheric nitrogen microaerophily, secretes plant-promoting phytohormones like auxins, and enhances root development and mineral uptake, rather than forming visible structural root nodules like Rhizobium.

40. (C) Jeevamrutha
Jeevamrutha is a liquid organic formulation prepared by fermenting cow dung, cow urine, pulse flour, jaggery, and a handful of undisturbed forest or rhizosphere soil in water. This specific combination provides essential carbon, nitrogen, and minerals that stimulate the rapid proliferation of indigenous soil microbes, enhancing nutrient mineralization and soil biological activity.

41. (D) By providing highly concentrated nitrogen and phosphorus through their organic droppings
Incorporating poultry into a crop-based system directly improves soil chemical fertility. Poultry droppings are highly concentrated organic manures containing rich amounts of nitrogen, phosphorus, and potassium compared to other livestock manures. As birds range through fields, they deposit these nutrients uniformly, facilitating immediate microbial mineralization and enriching the soil with plant-available mineral elements.

42. (A) Azadirachtin
Azadirachtin is the primary tetranortriterpenoid active compound found in the seeds and leaves of the neem tree, Azadirachta indica. It acts as a powerful botanical pesticide, functioning primarily as an insect growth regulator, antifeedant, and repellent. It disrupts the hormonal balance of insects, preventing molting and egg development without inducing rapid toxicity in non-target organisms.

43. (B) Lepidopteran caterpillars such as Helicoverpa armigera
Nuclear Polyhedrosis Virus is a highly specific baculovirus used as a biological control agent to target lepidopteran pests, particularly caterpillars like Helicoverpa armigera. When caterpillars ingest foliage treated with NPV, the virus replicates within their midgut cells, disintegrating internal tissues and causing lethal systemic infection, which is safe for non-target predators, parasitoids, and humans.

44. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Synthetic urea is strictly prohibited in organic farming because its industrial manufacture relies on the energy-intensive Haber-Bosch process, which utilizes fossil fuels to fix atmospheric nitrogen. This high-energy chemical processing and the application of highly soluble synthetic mineral salts run contrary to organic philosophy, which prioritizes biological nitrogen fixation and natural nutrient cycling.

45. (A) Thermal weeding (flaming)
Thermal weeding, also known as flaming, uses specialized propane burners to briefly expose young weed seedlings to extreme heat. This physical contact rapidly heats the plant cells, causing cell walls to rupture and the weed foliage to dehydrate and die within hours. This practice is ideal for stale seedbeds, destroying weed seedlings before crop emergence.

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desertification due to using zero chemical inputs.

(B) Conventional farming builds higher levels of soil organic carbon over several decades.

(C) Organic farming promotes soil biodiversity and resilience, though yield gaps may occur.

(D) Both agricultural systems are entirely identical in their impact on nitrate leaching.

****

NODIA

55. (B) Conversion period is a time-based transition phase, while a buffer zone is a physical barrier.
In organic farming standards, the conversion period represents a temporal phase required to restore soil biological health and purge chemical residues before a farm receives organic certification. Conversely, a buffer zone is a spatial physical barrier established along the field boundaries to prevent the active drift of prohibited agrochemicals from neighboring conventional agricultural lands.

56. (A) Crop residue → Livestock feed → Dung production → Composting → Field application
An ideal carbon cycle within an Integrated Organic Farming System proceeds systematically. Harvested crop residues are first fed to farm livestock. The animals digest this biomass, generating organic dung. This dung is then combined with bedding and composted under aerobic conditions to stabilize nutrients, and finally, the finished compost is applied back to fields to fertilize crops.

57. (D) Earthworm population density
Earthworm population density is widely regarded as a primary biological indicator of soil health during the transition to organic farming. Earthworms are highly sensitive to synthetic chemical applications and soil structural degradation. A rapid increase in their population indicates improved soil organic matter levels, reduced soil chemical toxicity, enhanced physical aggregation, and active biological nutrient cycling.

58. (A) Rapid growth and high nitrogen accumulation
Sunnhemp is a highly favored in-situ leguminous green manure crop due to its exceptionally rapid vegetative growth and high biomass production. In symbiotic association with Rhizobium bacteria, it fixes substantial quantities of atmospheric nitrogen, which, combined with its succulent tissue, decomposes rapidly upon soil incorporation to supply immediate mineral nutrients to subsequent crops.

59. (B) They secrete organic acids that lower localized soil pH, dissolving bound phosphates.)
Phosphate solubilizing bacteria improve plant phosphorus nutrition by secreting low molecular weight organic acids, such as gluconic or citric acids, into the rhizosphere. These acids lower localized soil pH and chelate bound mineral cations, which solubilizes insoluble inorganic phosphorus compounds like tricalcium phosphate into orthophosphate ions, which are readily absorbed by crop roots.

60. (B) Acidogenic and acetogenic bacteria
Anaerobic digestion in a biogas plant proceeds through distinct microbial phases. Before methanogens convert simple molecules to methane, complex organic polymers are broken down by hydrolytic, acidogenic, and acetogenic bacteria. These organisms metabolize proteins, carbohydrates, and lipids into volatile fatty acids, alcohols, carbon dioxide, and hydrogen, preparing the chemical substrate for methanogenic utilization.

61. (A) Seed treatment prior to sowing
Beejamrutha is a traditional indigenous liquid formulation prepared using cow dung, cow urine, lime, and soil, which is applied specifically as a seed and seedling treatment prior to sowing. It contains active bio-agents, enzymes, and plant hormones that coat the seed coat, protecting emerging seedlings from soil-borne and seed-borne pathogens while stimulating rapid germination.

62. (C) Epigeic
Epigeic earthworms are surface-dwelling, litter-feeding organisms that are highly efficient for commercial vermicomposting. Species such as Eisenia fetida inhabit the upper organic layer, showing high consumption rates of decomposing organic wastes, high tolerance to temperature variations, and rapid reproduction cycles. They feed primarily on fresh organic debris rather than deep mineral soil.

63. (D) Covering moist soil with clear plastic film to trap solar energy and heat weed seeds lethally
Soil solarization is a hydrothermal weed and disease management technique performed by covering moist, tilled soil with transparent polyethylene sheets during peak summer. The clear plastic film traps incoming solar radiation, generating extreme temperatures within the upper soil profile. This intense heat lethally inactivates weed seeds, pathogenic fungi, and nematodes, suppressing early weed competition.

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9. (D) Direct, intense sunlight accelerates the vermicomposting process by warming the worms.
Earthworms are highly sensitive to temperature and light, preferring cool, dark, and moist environments. Exposure to direct and intense sunlight raises the compost bed temperature beyond tolerable limits and dries out the bedding material, which lethally dehydrates and kills the earthworms. Therefore, vermicomposting beds require continuous shade and protective covering to maintain active biological decomposition.

10. (A) Groundnut oil cake
Organic manures are broadly categorized into bulky and concentrated types based on nutrient concentration and organic matter volume. Bulky manures, such as farmyard manure, compost, and green manure, contain low concentrations of plant nutrients in massive volumes. In contrast, oil cakes like groundnut oil cake are concentrated manures containing higher, readily mineralizable nutrient percentages.

11. (B) Phosphate Solubilizing Bacteria : Solubilizing rock phosphate to orthophosphate
Phosphate solubilizing bacteria enhance plant nutrition by secreting organic acids and enzymes that solubilize insoluble organic and inorganic phosphates, such as rock phosphate, into plant available orthophosphate forms. This biological process significantly improves phosphorus uptake in crops, especially in soils where phosphorus is chemically bound or fixed to calcium, iron, or aluminum minerals.

12. (B) II
Methanogenesis is the final phase of anaerobic digestion in a biogas plant, occurring under strictly anaerobic conditions. Methanogenic bacteria convert acetic acid, hydrogen, and carbon dioxide into methane gas. This metabolic process requires a neutral to slightly alkaline pH, typically between 6.5 and 7.5, and is severely inhibited in highly acidic conditions.

13. (A) Panchagavya
Panchagavya is an ancient Indian organic formulation prepared from five primary products of the cow, which are cow dung, cow urine, milk, curd, and ghee. These animal-derived ingredients are mixed and fermented with secondary organic additives like jaggery and banana, creating a liquid rich in beneficial microorganisms, macronutrients, micronutrients, and plant growth regulators.

14. (C) They feed on subsurface soil and organic matter, promoting horizontal structural aggregation.
Endogeic earthworms are subsurface dwelling organisms that feed on mineral soil mixed with organic matter. By burrowing horizontally through the upper soil layers, they mix organic debris with mineral soil particles. Their digestive processes and subsequent casts promote the formation of stable soil aggregates, thereby improving lateral aeration, water infiltration, and nutrient availability in the crop root zone.

15. (D) By letting early flushes of weeds germinate and then mechanically destroying them before crop sowing
The stale seedbed technique involves preparing the soil for planting, irrigating or waiting for rainfall to stimulate weed seed germination, and then destroying the emerged weed seedlings. This eradication is performed mechanically or thermally before the actual crop is sown, substantially reducing the viable weed seed bank in the topsoil and giving the crop a competitive advantage.

16. (A) Application submission → Field inspection → Review of farm records → Issuance of certificate
The third-party organic certification process follows a structured sequence. The farmer first submits a detailed application describing farm management. An accredited inspector then conducts a physical field inspection. Next, the certification body performs a comprehensive review of farm inputs and transaction records. Finally, if all organic standards are met, the official organic certificate is issued.

17. (B) Chrysanthemum cinerariifolium
Pyrethrins are natural insecticidal compounds extracted from the seed cases of the perennial flower Chrysanthemum cinerariifolium. This botanical pesticide is highly valued in organic agriculture due to its rapid contact action, strong knockdown effect on a wide range of insect pests, and quick biodegredation in the environment, which minimizes long-term chemical residues on treated food crops.

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ANSWERS

1. (B) A production system promoting agro-ecosystem health, biodiversity, and soil activity
Organic farming is defined as a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems by using agronomic, biological, and mechanical methods.

2. (D) The continuous improvement and restoration of degraded agricultural soil ecosystems
Regenerative agriculture prioritizes the active restoration and continuous rebuilding of soil organic matter, biodiversity, and overall ecosystem function. While organic farming focuses primarily on avoiding synthetic inputs and maintaining ecological balance, regenerative practices actively work to reverse degradation, enhance water retention, capture carbon in the soil, and restore the biological vitality of degraded agricultural landscapes.

3. (A) Provide quality of life, food sovereignty, and poverty reduction
The Principle of Fairness in organic agriculture emphasizes that relationships among those involved in farming should be characterized by equity, respect, justice, and stewardship. This principle asserts that human resources must be managed to provide an improved quality of life, establish food sovereignty, reduce poverty, and ensure social justice for all stakeholders involved in the system.

4. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
India possesses the largest number of organic producers globally, mostly consisting of smallholders with highly fragmented landholdings. Consequently, despite the vast number of active organic farmers, the cumulative certified organic land area in India remains significantly smaller than in countries like Australia, where massive, continuous tracts of extensive pastoral land dominate the certified organic statistics.

5. (A) Prevent unintended drift of synthetic chemicals from adjacent conventional fields
Buffer zones are physical barriers or designated land strips established around certified organic farms to prevent contamination from synthetic agrochemicals used on neighboring conventional fields. These zones help capture pesticide drift, fertilizer runoff, and other non-permitted substances, thereby protecting the integrity of the organic crop and ensuring compliance with stringent national and international certification standards.

6. (D) Relay cropping
Relay cropping is an intensive cropping system where a second crop is planted or sown directly into an existing standing crop before its harvest. This method ensures continuous vegetative ground cover, maximizes solar radiation interception, optimizes residual soil moisture utilization, and enhances biological nitrogen fixation or soil organic matter accumulation throughout consecutive growing seasons.

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7. (B) By utilizing the byproduct or waste of one enterprise as an input for another
Integrated Organic Farming Systems optimize resource use efficiency by cycling nutrients and organic matter within the farm boundary. In this design, waste products and byproducts from one farm enterprise, such as livestock manure or crop residues, directly serve as valuable inputs, like organic fertilizer or animal feed, for other components, minimizing external dependency and waste.

8. (A) P-3, Q-4, R-2, S-1
Soil bulk density serves as a key indicator of physical compaction. Cation exchange capacity measures the soil's capacity to retain and exchange crucial plant nutrients. Soil microbial biomass represents the active living biological component involved in organic matter recycling, while soil structure is defined by the physical arrangement and aggregation of individual soil particles.

27. (B) Sir Albert Howard
Sir Albert Howard is widely regarded as the father of modern organic agriculture. During his work in Indore, India, in the early twentieth century, he documented traditional Indian farming practices and developed the systematic Indore composting method, emphasizing the vital connection between soil organic matter health, plant nutrition, and overall animal and human well-being.

28. (A) P-3, Q-1, R-2, S-4
In biodynamic agriculture, preparation BD-501 is made from horn silica (quartz). Preparation BD-502 is prepared using fermented yarrow blossoms inside a stag's bladder. Preparation BD-503 is composed of chamomile flower heads fermented in cow intestines, and BD-504 is made using stinging nettle leaves, each designed to direct specific vital forces during composting.

29. (A) Principle of Care
The Principle of Care asserts that organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. This principle guides practitioners to select technologies with foresight, avoiding unpredictable risks like genetic modification or synthetic chemicals that could damage ecological networks.

30. (C) Jaivik Bharat
Jaivik Bharat is the unified domestic organic logo launched jointly by the Food Safety and Standards Authority of India, APEDA, and PGS-India. This logo serves to build consumer confidence and streamline marketing by providing a single, recognizable visual identity certifying that the organic food product complies with national standards for organic food safety.

31. (D) Produce harvested during this period can be sold with the standard "certified organic" label.
The conversion period represents the transitional timeframe required for a conventional farm to eliminate chemical residues and establish ecological biological activity. Crops harvested during this conversion process cannot carry the fully certified organic label. Instead, they must be designated and sold as in-conversion produce, ensuring consumers are not misled before the farm achieves complete certification status.

32. (C) III
Green manures are succulent, leafy crops incorporated into the soil to improve organic matter and nitrogen levels. To decompose rapidly and release nutrients effectively, these crops must have narrow carbon-to-nitrogen ratios, typically between 10:1 and 20:1. Plants with wide ratios, such as mature straw exceeding 80:1, lead to nutrient immobilization rather than fertilization.

33. (B) Seeds of the subsequent crop are sown before the harvest of the preceding crop.
Relay cropping is distinguished from other multiple cropping patterns by the overlapping lifecycles of consecutive crops on the same field. The second crop is planted during the reproductive phase of the active first crop. This practice optimizes the use of solar radiation, vertical growing space, residual fertilizer, and residual soil moisture before the first crop is harvested.

34. (D) Microbes consuming available soil nitrogen to decompose high C:N ratio plant residues
When raw organic materials with high carbon-to-nitrogen ratios are applied to soil, soil microbes multiply rapidly to decompose the abundant carbon. Because the crop residues contain insufficient nitrogen to meet microbial dietary needs, these microorganisms absorb and immobilize inorganic nitrogen from the surrounding soil solution, causing a temporary nitrogen deficiency in growing plants.

35. (A) Mineralization
Mineralization is the critical biological process by which active soil microorganisms decompose complex, insoluble organic nitrogen compounds present in manures and crop residues, converting them into plant-available inorganic forms such as ammonium. This biochemical transformation is driven by microbial enzymes and is heavily influenced by soil moisture, temperature, and aeration levels.

36. (A) I, II, IV, III
The commercial composting process follows a systematic sequential timeline. It begins with selecting the composting site and digging the pits. Next, carbonaceous and nitrogenous feedstock materials are layered inside the pits. Regular turning is then conducted to regulate temperature and maintain aerobic conditions,

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18. (D) Biological control of soil-borne fungal pathogens
Trichoderma viride is a soil dwelling, beneficial fungus widely utilized in organic farming for biological disease control. It acts against soil borne fungal pathogens through mechanisms such as mycoparasitism, enzyme secretion, and nutrient competition. Applying this bio fungicide protects seeds and plant roots from destructive diseases like root rot, damping off, and collar rot caused by Pythium or Rhizoctonia.

19. (A) Secondary metabolites and antioxidants
Organically grown plants often experience natural environmental pressures, which stimulates the synthesis of secondary metabolites and polyphenolic antioxidants. These biochemical compounds are essential components of the plant's natural defense mechanism against pests and environmental stress. Comparative nutritional analyses consistently demonstrate that organic produce contains higher levels of these beneficial substances compared to conventional food.

20. (C) Ionizing radiation for shelf-life extension
Under National Programme for Organic Production guidelines, ionizing radiation is strictly prohibited for processing and preserving organic food. This restriction is a fundamental tenet of organic food integrity, aiming to preserve the natural biological qualities of agricultural produce. Organic operations must instead rely on physical, mechanical, or thermal post-harvest preservation methods, such as temperature control.

21. (A) APEDA
The Agricultural and Processed Food Products Export Development Authority acts as the national secretariat for implementing the National Programme for Organic Production in India. APEDA evaluates and accredits certification bodies, maintains the regulatory framework, manages the TraceNet database system, and represents Indian organic standards in bilateral and international organic trade equivalency agreements.

22. (D) Local peer groups consisting of fellow farmers
The Participatory Guarantee System operates on a peer-review model where verification of organic compliance is performed directly by fellow farmers organized in local peer groups. This localized approach builds trust, facilitates knowledge sharing, and eliminates the expensive professional auditor costs associated with third-party certification, making organic verification highly accessible and affordable for rural smallholders.

23. (B) To maintain an online registry tracing organic products to export
TraceNet is an online, internet-based traceability system developed by APEDA to monitor and trace the entire supply chain of organic products exported from India. It records essential information regarding farm registration, organic certifications, laboratory test reports, and transaction certificates, ensuring the integrity of the organic supply chain and preventing fraudulent organic claims.

24. (C) (A) is true but (R) is false.
The biodynamic formulation BD-500 is cow horn manure, which is applied directly to the soil to stimulate root growth, microbial life, and humus formation. In contrast, BD-501 is the silica-based preparation made from finely ground quartz, which is sprayed as a fine foliar mist onto crop leaves to enhance light absorption and photosynthesis.

25. (D) Increased vulnerability to global chemical price fluctuations
Organic farming systems reject the use of synthetic chemicals and mineral fertilizers, significantly reducing farmer dependency on global chemical industries. Consequently, organic producers are shielded from fluctuations in global synthetic fertilizer and pesticide prices. Instead, they rely on localized nutrient cycling, crop rotations, and biological pest management, which enhances farm self-reliance and economic stability.

26. (A) The ratio of crop yield increase to nutrient applied
Agronomic nutrient use efficiency measures the efficiency with which crops convert applied nutrients into economic yield. It is calculated by dividing the difference in crop yield between fertilized and unfertilized plots by the total amount of specific nutrients applied through organic manures or composts, helping farmers optimize organic fertilizer application rates.

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46. (C) Contamination by human pathogens such as E. coli and Salmonella species
Composting livestock manures before applying them to fresh produce fields is critical for food safety. The high temperatures generated during the aerobic thermophilic phase of composting, usually between 55 and 65 degrees Celsius, effectively sanitize the manure, destroying enteric human pathogens like Escherichia coli and Salmonella, which prevents direct microbial contamination of edible crops.

47. (D) Physiological senescence
Physiological senescence is the natural, genetically programmed aging process of plant tissues post-harvest. It is characterized by progressive cell membrane degradation, respiratory bursts, and biochemical breakdown of structural proteins, carbohydrates, and organic acids. Managing ambient temperature, humidity, and atmospheric gases after harvest helps slow this respiration and senescence, preserving quality in organic produce.

48. (A) P-4, Q-3, R-2, S-1
In biological pest control, ladybird beetles act as active generalist predators of soft-bodied insect pests like aphids. Trichogramma wasps function as highly specialized egg parasitoids. Pseudomonas fluorescens serves as a bacterial antagonist suppressing soil pathogens, and Beauveria bassiana acts as an entomopathogenic fungus that penetrates insect cuticles to cause lethal white muscardine disease.

49. (B) The specific phases of the moon and planetary positions
In biodynamic farming, agricultural activities are carefully timed in accordance with cosmic and astronomical rhythms, including lunar phases, planetary alignments, and the zodiac. This practice is based on the philosophy that cosmic gravitational and formative forces influence water movement, plant sap flow, seed germination, root development, and overall plant vital physiological processes.

50. (D) It significantly reduces the financial burden of certification costs for smallholder farmers.
The Participatory Guarantee System offers a decentralized, peer-led verification model that substantially reduces the financial and administrative burdens of organic certification. By replacing expensive external third-party inspections with local peer reviews and collective group assurance, PGS-India makes organic certification affordable and attainable for resource-poor smallholder farmers, thereby facilitating domestic organic market access.

51. (A) The ratio of crop economic yield to the total volume of water consumed
Water use efficiency is an agronomic index that quantifies how effectively a crop converts water into economic output. It is defined as the ratio of crop economic yield, such as grain or biomass weight, to the total volume of water consumed by the crop through transpiration, soil evaporation, and drainage over the growing season.

52. (A) I, II and IV
Ecological farming focuses on designing sustainable agricultural systems by integrating key ecological principles. It emphasizes the enhancement of biodiversity, biological nutrient recycling, and natural soil conservation. It actively avoids synthetic agrochemicals, such as chemical weedicides, and focuses on closing local nutrient loops through on-farm resource integration rather than specializing in export monoculture cropping.

53. (A) Push-pull strategy
The push-pull strategy is an ecological pest management approach that integrates repellent companion crops and attractive trap crops. Intercropped companion plants emit volatile chemicals that repel, or push, pests away from the main cash crop. Concurrently, trap crops planted on the field border attract, or pull, those insects away, facilitating localized control and minimizing pest damage.

54. (D) Soil, plant, animal, human, and planet as one single and indivisible ecosystem
The IFOAM Principle of Health asserts that organic agriculture must sustain and enhance the collective health of soil, plants, animals, humans, and the planet. It emphasizes that these individual components are connected within a single, indivisible ecological system, meaning that the health of individuals and communities cannot be separated from the health of the broader ecosystem.

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2013

201. Which post-harvest handling practice involves maintaining a continuous temperature-controlled environment from the point of harvest to the consumer, crucial for perishable organic produce?
(A) The Hot Water Chain
(B) The Cold Chain
(C) Ambient Curing
(D) Sun Drying

2013

202. The National Programme for Organic Production (NPOP) provides standard guidelines that are formally recognized for equivalence by which of the following international entities?
(A) The World Bank and its global affiliates
(B) The European Commission and Switzerland
(C) The United Nations Security Council group
(D) The International Monetary Fund agency

2002

203. Which is the most significant disadvantage of relying entirely on third-party certification for a small, resource-poor farmer producing for local rural markets?
(A) The high financial cost and complex documentation required
(B) The complete lack of global recognition for third-party certificates
(C) The prohibition of growing any edible crops
(D) The mandatory requirement to purchase foreign machinery

2023

204. The TraceNet software system relies on the generation of a specific document by the certification body for every sold batch of organic produce. This document is the:
(A) Origin Guarantee Slip
(B) Farmer's Identity Card
(C) Transaction Certificate
(D) Soil Health Card report

2024

205. In the context of biodynamic agriculture, what is the core philosophical concept regarding the farm entity?
(A) The farm is an industrial factory for extracting biomass.
(B) The farm must completely depend on cosmic energy, ignoring soil completely.
(C) The farm is merely a financial asset to be maximized quarterly.
(D) The farm is viewed as a single, self-sustaining living organism.

2002

206. Organic agriculture often aims to improve profitability for the farmer through which market mechanism?
(A) By producing massive surpluses to dump on global agricultural markets
(B) By relying entirely on direct governmental crop price-fixing schemes
(C) By capturing a premium price from consumers for ecologically grown food
(D) By monopolizing all local and regional food distribution networks

2011

207. Which analytical method would most accurately estimate the Organic Nutrient Use Efficiency of an applied compost over a single growing season?
(A) Measuring and recording the exact total weight of the compost applied to soil
(B) Calculating recovery fractions by comparing uptake in treated and control plots
(C) Analyzing the leaf nitrogen content or color darkness of final harvested grain
(D) Weighing and monitoring the total amount of irrigation water applied to fields

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2012

208. The concept of "ecological intensification" in organic farming refers to:
(A) Intensively applying mined rock phosphates and minerals to soil
(B) Intensively tilling the agricultural soil to accelerate carbon loss
(C) Packing livestock tightly into enclosed industrial factory farms
(D) Maximizing yields through enhanced management of ecosystem services

2018

209. Which factor most limits the immediate availability of nitrogen when fresh, high-lignin farmyard manure is applied to the soil?
(A) Microbial immobilization of nitrogen during breakdown of carbon-rich material
(B) High initial levels of water-soluble nitrates present within the dry manure
(C) The highly alkaline pH levels commonly associated with all farmyard manures
(D) The instantaneous volatilization of nitrogen compounds into gaseous N_2 forms

2008

210. Which statement represents a true inference regarding the long-term sustainability of organic farming versus conventional farming?
(A) Organic farming invariably leads to

64. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
The botanical insecticide Pyrethrum causes extremely rapid knockdown in target insect pests because its active pyrethrins function as powerful neurotoxins. These compounds rapidly bind to voltage-gated sodium channels along the insect's nerve axons, preventing channel closure. This action leads to continuous, repetitive nerve discharges, resulting in immediate paralysis and death of the pest.

65. (B) A parasitoid develops on or inside a single host, killing it, whereas a predator consumes multiple prey individuals.
In biological pest control, predators and parasitoids utilize distinct hunting and survival strategies. A predator is a free-living organism that directly captures and consumes multiple prey individuals during its lifetime. Conversely, a parasitoid is an insect whose immature stage develops on or within a single host organism, eventually killing the host before emerging as an adult.

66. (D) Nitrates
Organically grown vegetables consistently display significantly lower concentrations of free nitrates compared to conventionally grown crops. Conventional farming relies heavily on highly soluble synthetic nitrogen fertilizers, which leads to rapid, excessive plant nitrate accumulation. In organic farming, nitrogen is released slowly through organic matter mineralization, allowing plants to assimilate nitrogen steadily into proteins.

67. (A) Heal surface wounds and thicken the skin to reduce water loss and pathogen entry
Curing is a critical post-harvest practice for root and tuber crops, conducted by exposing them to high temperatures and relative humidity for several days. This treatment stimulates suberization, healing surface cuts and thickening the outer skin. This physical barrier reduces post-harvest moisture loss and prevents the entry of rot-inducing pathogens during storage.

68. (A) P-4, Q-3, R-2, S-1
The Indian organic standards framework is highly structured. The National Programme for Organic Production regulates export certification standards. PGS-India manages the domestic peer-review certification process. Jaivik Bharat represents the unified domestic organic logo of FSSAI, and TraceNet serves as the mandatory online traceability software monitoring organic export supply chains across the country.

69. (A) Ensuring animal welfare by allowing natural behaviors and living conditions
Animal welfare is an essential ethical core value of global organic agriculture. Certified organic standards mandate that livestock must be reared under conditions that respect their natural behaviors, providing access to open pastures, natural light, fresh air, clean water, and organic feed, while strictly prohibiting confinement or routine synthetic chemical growth promoters.

70. (D) Enhance light metabolism, photosynthesis, and crop quality
The biodynamic preparation BD-501 is horn silica, prepared by grinding quartz crystals into a fine powder and stuffing it into cow horns buried during summer. It is applied as a fine foliar mist directly to crop leaves to enhance light metabolism, accelerate photosynthesis, regulate vegetative growth, and improve the quality, flavor, and shelf life of harvestable parts.

71. (B) By utilizing slow-release composts synchronized with critical crop growth stages
Improving organic nutrient use efficiency requires aligning soil nutrient availability with crop nutrient demand. This is achieved by utilizing stable, slow-release composts and organic manures. Unlike raw manures, processed composts release nitrogen and phosphorus gradually through microbial mineralization, which minimizes environmental leaching and ensures adequate nutrient supply during critical crop growth phases.

72. (A) I
Under organic standards, parallel production, which is the simultaneous cultivation of the same crop variety organically and conventionally on the same farm, is strictly prohibited. This rule prevents the commingling of organic and conventional produce, reduces chemical contamination risks, and simplifies auditing. Split operations must grow visually distinguishable crop varieties to maintain regulatory compliance.

73. (D) Mixed cropping
Mixed cropping is defined as growing two or more crops simultaneously on the same piece of

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149. (B) Indole Acetic Acid and Gibberellic Acid
Panchagavya is a traditional liquid organic formulation made from five cow-derived products. Scientific analyses have demonstrated that this bio-formulation contains significant concentrations of naturally occurring plant growth hormones, including Indole Acetic Acid and Gibberellic Acid. These hormones help stimulate root development, enhance cell elongation, and promote vegetative growth in treated crops.

150. (C) Higher levels of plant-available nutrients and microbial counts
Earthworm casts are highly valued in organic farming because they exhibit distinct chemical and biological advantages over the surrounding bulk soil. The passage of organic matter and mineral soil through the earthworm gut enriches the resulting casts with highly soluble, plant-available nutrients and elevates active microbial populations, enhancing soil fertility.

151. (D) Manipulating crop spacing, varieties, and sowing dates to outcompete weeds
Ecological weed management in organic farming focuses on designing farming systems that naturally suppress weed growth. By manipulating crop row spacing, selecting competitive crop varieties with rapid early canopy development, and adjusting sowing dates, farmers can give crops a competitive advantage over emerging weeds, reducing the need for intensive mechanical control.

152. (A) Neem
Neem trees produce azadirachtin, a tetranortriterpenoid compound that serves as an effective botanical pesticide in organic farming. Azadirachtin does not cause immediate knockdown of insect pests. Instead, it acts as a systemic regulator, disrupting larval hormonal systems to prevent proper moulting and pupation, while also acting as a strong deterrent to feeding.

153. (B) It must be ingested to let its protein crystals rupture the caterpillar midgut.
Bacillus thuringiensis is a widely used microbial biopesticide in organic systems. Its effectiveness relies on the target insect ingesting the bacterial spores and crystalline proteins. Once inside the alkaline environment of the caterpillar midgut, these proteins dissolve and bind to specific receptors, creating pores that rupture the gut wall and lead to paralysis and death.

154. (B) Conjugated Linoleic Acid
Comparative biochemical studies demonstrate that milk produced from organically managed dairy herds often contains higher concentrations of Conjugated Linoleic Acid than conventional milk. This nutritional difference is primarily attributed to the organic livestock management standards, which mandate significant grazing on fresh pasture and forage, which naturally elevates beneficial fatty acids in milk.

155. (A) Use of hot water treatments or plant essential oil coatings
Post-harvest decay in organic fruits must be managed without synthetic chemical fungicides. Physical treatments, such as brief hot water dips, are permitted because they effectively destroy surface fungal spores. Additionally, coating fruits with natural, plant-derived essential oils helps restrict fungal growth and reduces respiration, safely extending the storage shelf life.

156. (C) Ministry of Commerce and Industry
The Agricultural and Processed Food Products Export Development Authority is a statutory body established by the Government of India. Operating under the administrative control of the Ministry of Commerce and Industry, APEDA serves as the secretariat for the National Programme for Organic Production, managing the accreditation of certification bodies and overseeing organic exports.

157. (D) The entire Local Group risks losing certification due to collective responsibility.
The Participatory Guarantee System relies heavily on peer monitoring and collective responsibility. If an individual farmer within a registered Local Group defaults on organic standards, the non-compliance affects the entire group. Because certification is granted collectively, the entire Local Group risks losing its certified organic status if corrective actions are not taken.

158. (C) Certified organic food products sold within India
The Jaivik Bharat logo is a mandatory regulatory mark introduced by the Food Safety and Standards Authority of India. It represents a unified organic food identity and must be

NODIA

transport chain in mitochondria by inhibiting Complex I, blocking adenosine triphosphate synthesis, which causes cellular energy failure and rapid death in target pests.

83. (A) White muscardine disease
Beauveria bassiana is an entomopathogenic soil fungus used as a biological pesticide. When its asexual spores, or conidia, contact the cuticle of susceptible insect hosts, they germinate and penetrate the insect's body using specialized hydrolytic enzymes. Once inside, the fungus proliferates, releasing toxins and causing white muscardine disease, characterized by white mycelial growth covering the dead insect.

84. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Organically grown fresh fruits can display a shorter post-harvest shelf life compared to conventional products if effective physical conservation techniques are not implemented. Organic regulations strictly prohibit synthetic post-harvest fungicides and chemical wax coatings, which are commonly used in conventional agriculture to suppress decay fungi, prevent transpiration, and extend shelf life during distribution.

85. (A) It must be certified by an APEDA-accredited certification body under NPOP standards.
To legally export organic food products from India to international markets like the European Union or the United States, the consignment must be certified by an APEDA-accredited certification body. This process verifies that the production and handling comply with the National Programme for Organic Production standards, which are recognized under international bilateral equivalence agreements.

86. (D) Local Group (LG) of at least 5 interacting farmers
The basic operational and structural unit of the Participatory Guarantee System is the Local Group, which must consist of at least five interacting organic farmers from the same cluster. This group is responsible for conducting peer evaluations, maintaining collective farm records, ensuring mutual compliance with organic standards, and recommending certification for its member farmers.

87. (B) No less than 95% of its ingredients are of certified organic origin.
Under National Programme for Organic Production standards, a processed food product can only be labeled and sold as a "Produce of Organic Agriculture" if at least ninety-five percent of its raw ingredients by weight, excluding added water and salt, are of certified organic origin, ensuring the chemical and ecological integrity of processed organic foods.

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88. (A) P-2, Q-4, R-3, S-1
In biodynamic agriculture, preparation BD-500 is cow horn manure, applied to the soil to stimulate root growth. Preparation BD-501 is horn silica, sprayed on foliage to enhance photosynthesis. Preparation BD-505 is made from oak bark buried in animal skulls, and BD-508 is a liquid extract of horsetail used as a preventive foliar spray for fungal disease control.

89. (D) It promotes self-reliance by utilizing locally available, low-cost farm resources.
The utilization of Indigenous Technical Knowledge formulations, such as Panchagavya and Jeevamrutha, offers substantial socio-economic benefits by promoting farm self-reliance. Because these formulations are prepared using locally available, low-cost farm resources, they drastically reduce smallholder reliance on expensive, imported commercial inputs, which lowers overall production costs and enhances rural household financial resilience.

90. (A) The initial transition phase marked by yield dips and high labor demand
A major socio-economic barrier limiting the large-scale adoption of organic farming is the initial transition phase, which is often characterized by significant crop yield reductions and increased physical labor requirements. Smallholder farmers transitioning from conventional systems often lack the financial buffer to absorb these temporary yield losses before the soil biological fertility is fully restored.

91. (B) Establishing robust local supply chains and community-supported agriculture (CSA) systems
The concept of food miles measures the total distance food travels from production to consumption, reflecting its environmental carbon footprint. Building robust localized supply chains, such as community-supported agriculture networks and farmers' markets, minimizes food

land without any distinct row arrangement. This multiple cropping strategy is commonly used to minimize farming risks, provide insurance against total crop failure under rainfed conditions, enhance vertical space utilization, and promote biodiversity within the local agro-ecosystem.

74. (A) A crop grown to attract insects away from the main economic crop
A trap crop is a designated companion crop planted along field borders or in specific patterns to attract insect pests away from the primary economic crop. By utilizing a crop that is highly attractive to target pests, farmers can concentrate the insect populations in localized border areas, where they can be managed using targeted biological or physical control methods.

75. (B) A rise in internal temperature (thermophilic phase) reaching 55-65 degrees Celsius
A rapid rise in the internal temperature of a compost pile, typically reaching 55 to 65 degrees Celsius, is the most reliable indicator of active organic matter decomposition. This thermophilic phase is driven by heat-generating metabolic activities of saprophytic bacteria and actinomycetes as they digest easily degradable organic compounds, which effectively sanitizes pathogens and weed seeds.

76. (B) II, III, I, IV
Decomposition of organic matter proceeds through a defined biological sequence. Soluble organic matter is first colonized by active saprophytic microflora. These microbes rapidly metabolize simple water-soluble sugars and amino acids. This phase is followed by the humification of complex, resistant biopolymers like lignin and cellulose, culminating in the slow mineralization of stable humus into inorganic plant nutrients.

77. (A) They contain nitrification-inhibiting properties while supplying steady nitrogen
Concentrated organic manures like neem cake are highly valued because they provide substantial nitrogen while containing natural nitrification-inhibiting compounds, such as epinimbin. These bioactive molecules slow down the microbial conversion of ammonium into highly leachable nitrate, thereby reducing nitrogen losses through leaching and denitrification and ensuring a steady, long-term nitrogen supply to crops.

78. (C) It is a free-living, associative microaerophilic bacterium fixing nitrogen in grasses and cereals.
Azospirillum is a highly beneficial, free-living, associative microaerophilic diazotrophic bacterium that actively colonizes the rhizosphere and inner root tissues of non-leguminous plants, including grasses, maize, sorghum, and wheat. It fixes atmospheric nitrogen in close proximity to plant roots, secretes growth-promoting phytohormones like auxins, and improves overall root system development and mineral uptake efficiency.

79. (D) Its nitrogen is predominantly in a readily plant-available form compared to raw dung.
Biogas slurry is a highly valuable organic liquid fertilizer because the anaerobic digestion process mineralizes complex organic nitrogen present in raw dung. Consequently, the nitrogen in the resulting digested slurry is predominantly in the form of ammonium, which is immediately available for crop uptake compared to the slowly mineralizing organic nitrogen in raw dung.

80. (C) To provide a readily available carbon source for rapid microbial multiplication
In the preparation of Panchagavya, adding organic carbon sources like jaggery, sugarcane juice, or ripe bananas is essential for microbial fermentation. These ingredients supply readily metabolizable simple sugars, which act as energy sources driving the rapid multiplication and growth of beneficial bacteria, yeasts, and actinomycetes present in the cow dung and urine.

81. (B) Adopting narrower row spacing to ensure early canopy closure
Cultural weed management focuses on modifying the crop growing environment to favor crop competition over weeds. Adopting narrower row spacing is a prime cultural strategy that accelerates vegetative canopy closure. This rapid shading blocks sunlight from reaching the soil surface, suppressing the germination and development of photoblastic weed seeds without requiring mechanical or thermal control.

82. (D) Inhibiting cellular respiration in the mitochondria
Rotenone is a naturally occurring botanical insecticide extracted from the roots of Fabaceae family climbers. It exerts its highly toxic effect by acting as a cellular respiration inhibitor. Specifically, rotenone disrupts the electron

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101. (A) To form symbioses with roots, expanding surface area for enhanced phosphorus and water uptake
Vesicular Arbuscular Mycorrhizae form mutualistic symbiotic associations with the roots of most agricultural crop plants. The fungal hyphae extend far beyond the root depletion zone, vastly expanding the effective soil surface area. This physical expansion significantly enhances the absorption and translocation of immobile nutrients, particularly phosphorus, and improves overall crop water uptake.

102. (D) It is optimal in mesophilic or thermophilic ranges, slowing down in cold climates.
Methanogenesis is a temperature-sensitive biochemical process driven by specialized anaerobic archaea. The rate of biogas production peaks within distinct thermal ranges, which are the mesophilic range, between 35 and 40 degrees Celsius, and the thermophilic range, between 50 and 55 degrees Celsius. Digestion rates slow down significantly in cold climates, requiring thermal insulation.

103. (B) Panchagavya
Panchagavya is highly recommended as a foliar application rather than strictly as a soil fertilizer. When sprayed onto crop leaves as a diluted solution, it is rapidly absorbed, supplying essential macronutrients, micronutrients, amino acids, and plant growth-promoting hormones like auxins and gibberellins, which directly enhances photosynthetic activity, plant growth, and disease resistance.

104. (B) II, III and IV
Earthworms are classified into distinct ecological groups based on their burrowing and feeding behaviors. Anecic species construct permanent vertical burrows and pull surface organic litter down into the soil. Endogeic species construct horizontal subsurface channels, feeding on humified organic matter, and vermiwash is a liquid nutrient-rich extract collected from active vermicompost bins.

105. (D) Shallow cultivation of the entire field after sowing but before crop seedlings emerge
Blind tillage is a mechanical weed control technique performed by cultivating the entire field at a very shallow depth after the crop has been sown but before the crop seedlings have emerged. This operation breaks up the soil crust and destroys emerging weed seedlings in the thread stage without damaging the deeper, ungerminated crop seeds.

106. (B) Rotenone
Rotenone is a naturally occurring organic compound derived from the roots of several tropical plant species, particularly those in the Derris genus. It functions as a broad-spectrum insecticide and piscicide by interfering with cellular respiration in mitochondria. Its use is strictly regulated under organic standards to prevent harm to non-target aquatic organisms.

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107. (A) By producing iron-sequestering siderophores to starve pathogens
Pseudomonas fluorescens functions as an effective biological control agent by colonizing plant root systems. This beneficial bacterium produces specialized low-molecular-weight molecules called siderophores, which chelate and sequester available ferric iron in the rhizosphere. By reducing iron availability, it starves soil-borne pathogens, effectively preventing them from proliferating and infecting plant hosts.

108. (C) The stable nitrogen isotope ratio (15N/14N) in the crop tissue
Organic crops rely on natural organic fertilizers such as animal manure or compost, whereas conventional agriculture heavily utilizes synthetic nitrogen fertilizers. Because organic and synthetic nitrogen sources possess distinct isotopic profiles, analyzing the stable nitrogen isotope ratio in harvested crop tissues serves as a reliable scientific method to verify the authenticity of organic labeling.

109. (D) Hermetic storage utilizing sealed bags to deplete oxygen levels
Hermetic storage is a highly effective, chemical-free physical method for controlling insect pests in stored grains. By sealing grains in airtight bags or containers, the respiration of the grains and any present insects rapidly depletes the internal oxygen levels while increasing carbon dioxide, ultimately suffocating the pests and preserving organic grain quality.

110. (C) The accredited certification body that certified the project
Under the National Programme for Organic Production, transaction certificates are essential administrative documents that verify the

129. (A) Pathogen and weed seed load
Vermicomposting utilizes earthworms and microorganisms to biochemically convert raw organic wastes into nutrient-rich worm castings. The digestive passage of materials through the earthworm gut, combined with microbial activity, significantly reduces the viability of harmful enteric pathogens and weed seeds, resulting in a safe, biologically stable, and highly concentrated organic fertilizer.

130. (C) To suppress weeds through earlier crop canopy competition
Increasing the seeding rate of organic wheat above conventional recommendations is a strategic cultural weed management technique. By establishing a dense plant stand early in the growing season, the wheat crop quickly closes its canopy. This rapid canopy closure shades the soil surface, suppressing weed germination and growth through direct competition for light.

131. (A) Neem seed kernel extract
Neem seed kernel extract is a widely used botanical formulation in organic farming. Its primary active component, azadirachtin, does not function as a rapid contact poison. Instead, it acts as an insect growth regulator and powerful antifeedant, disrupting hormone systems responsible for larval moulting and rendering treated crop foliage unpalatable to pests.

132. (D) Inundative biological control
Releasing Trichogramma chilonis wasps in sugarcane fields is a classic inundative biological control strategy. This tiny parasitic wasp targets and parasitizes the eggs of destructive moth borers. Mass-producing and releasing these wasps in large numbers during peak pest activity periods ensures rapid suppression of the pest population before they can cause economic crop damage.

133. (B) Transmission of enteric pathogens to raw vegetables
Utilizing animal manure in organic agriculture presents a food safety risk if the composting process is incomplete. Raw or poorly composted manure can harbor dangerous enteric pathogens like Escherichia coli and Salmonella. If applied directly to fields, these pathogens can contaminate fresh, raw vegetables, presenting a severe health risk to consumers.

134. (C) Removes field heat, slowing respiration and delaying senescence
Pre-cooling fresh organic vegetables immediately after harvest is a critical step in preserving post-harvest quality. This process rapidly removes ambient field heat, which significantly lowers the crop's physiological respiration rate. By slowing metabolic activity and reducing moisture loss, pre-cooling delays natural senescence, minimizes weight loss, and extends storage shelf life.

135. (D) Ministry of Commerce and Industry
The National Programme for Organic Production establishes national standards, certification procedures, and guidelines for organic farming in India. This regulatory framework is managed and implemented under the administrative control of the Ministry of Commerce and Industry, with the Agricultural and Processed Food Products Export Development Authority serving as the main secretariat.

136. (A) II
Third-party organic certification is highly structured and widely recognized for international exports, but it is not inexpensive. The high costs and demanding record-keeping requirements make it difficult for individual small and marginal farmers to afford. To address this, group certification models and the Participatory Guarantee System are utilized for small-scale domestic growers.

137. (B) A lot number linked to a digital Transaction Certificate
TraceNet is an internet-based electronic system used by APEDA to track and monitor the export of organic products from India. To ensure complete traceability throughout the supply chain, the system generates a unique transaction certificate. This digital document contains a unique lot number that links the exported consignment directly to the certified farm.

138. (A) BD 500
Preparation BD 500, commonly known as horn manure, is a foundational biodynamic soil preparation. It is made by filling high-quality cow horns with fresh, organic cow manure and burying them in fertile soil during the winter. This process allows the manure to ferment and absorb cosmic forces, creating a biologically active soil conditioner.

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a high risk of accidental mixing or intentional substitution of conventional produce for organic, certification bodies impose extremely strict monitoring, segregation, and record-keeping requirements.

120. (A) By breaking pathogen life cycles through the introduction of non-host crop species
Crop rotation is a fundamental cultural practice in organic agriculture used to manage soil-borne plant pathogens. By systematically alternating susceptible crops with non-host plant species, the specific host plants required by pathogens to survive and reproduce are removed. This effectively disrupts their life cycles, leading to a natural decline in pathogen populations.

121. (B) A fast-growing crop grown between main crops to utilize nutrients and prevent leaching
A catch crop is a fast-growing plant species cultivated in the brief period between the harvest of a primary crop and the planting of the next. Its main ecological role is to rapidly absorb mobile soil nutrients, particularly nitrates, preventing them from leaching into deep groundwater during periods when fields would otherwise lie bare.

122. (B) To provide fodder, fuel, green manure, and windbreaks
Planting multipurpose tree species along farm bunds is a strategic agroforestry technique in integrated organic systems. These deep-rooted trees serve several practical functions, including acting as physical windbreaks to prevent soil erosion, providing high-quality livestock fodder, supplying organic green manure for the fields, and generating wood for local household fuel needs.

123. (A) The soil's capacity to resist erosion and maintain porosity under rain impact
Soil aggregate stability is a vital physical indicator of overall soil health in organic systems. Stable soil aggregates resist degradation caused by raindrops and tillage machinery, preventing surface crusting. Maintaining high aggregate stability ensures that the soil retains its porosity, which facilitates optimal water infiltration, gas exchange, and root growth.

124. (B) I, III and IV
Bulky organic manures, including farmyard manure, are characterized by their ability to supply vast quantities of organic matter, which enhances soil physical structures and boosts water-holding capacity in light, sandy soils. However, they contain relatively low concentrations of primary plant nutrients compared to their overall bulk and physical mass.

125. (D) At the active flowering stage, before they become overly woody
Green manure crops must be incorporated into the soil at the active flowering stage to achieve optimal nitrogen release. At this specific physiological phase, the plants contain their maximum nutrient concentration and have a low carbon-to-nitrogen ratio. This promotes rapid microbial decomposition without the nutrient immobilization associated with older, woody plant tissues.

126. (C) Azotobacter species
Azotobacter species are free-living, aerobic bacteria that inhabit the soil. Unlike symbiotic bacteria like Rhizobium, they do not require a host plant to function. Instead, they independently fix atmospheric nitrogen in the soil using the enzyme nitrogenase, while simultaneously secreting beneficial plant growth regulators that stimulate crop root development.

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127. (B) The slurry features a narrower C:N ratio and more available ammoniacal nitrogen.
Anaerobic digestion of animal manure in a biogas plant produces a processed slurry with distinct biochemical advantages over raw manure. The digestion process decomposes complex organic carbon compounds, narrowing the carbon-to-nitrogen ratio. Consequently, the resulting slurry contains highly concentrated, readily available ammoniacal nitrogen, providing rapid nutrition when applied to organic crops.

128. (D) To introduce a diverse inoculum of indigenous beneficial microbes
Jeevamrutha is a fermented liquid organic formulation designed to enrich soil biological activity. Incorporating undisturbed forest soil during its preparation is vital because forest soils contain a diverse, resilient, and highly active population of indigenous beneficial microorganisms. This microbial inoculum rapidly multiplies in the mixture, helping to restore biological functions when applied.

organic status of a specific batch of produce during sales or exports. These certificates are issued exclusively by accredited certification bodies, which verify that the consignment aligns perfectly with organic standards before it leaves the farm.

111. (B) Small and marginal farmers focused on local and domestic markets
The Participatory Guarantee System serves as an alternative organic certification method designed specifically for small-scale, marginal farmers selling to local communities. Relying on peer review and active community participation instead of expensive third-party inspectors, this system fosters trust and ensures compliance with organic standards without imposing heavy financial burdens on local growers.

112. (D) I and III
The Jaivik Bharat logo is a unified certification mark issued by the Food Safety and Standards Authority of India to denote authentic organic food products. It is legally mandated for all certified organic foods distributed inside India, confirming compliance with national organic regulations, but it does not restrict sourcing exclusively to wild forest harvesting.

113. (A) It is believed to draw vital forces down into the soil to promote root growth and development.
Biodynamic agriculture utilizes a specialized astronomical calendar to guide critical farming operations. During the descending moon phase, cosmic and planetary forces are believed to influence the movement of sap downward into the lower parts of the plant. Consequently, this period is highly recommended for tasks like transplanting, root pruning, and applying soil preparations.

114. (C) Yield decline due to sudden chemical withdrawal before organic price premiums can be realized
Transitioning from conventional to organic farming often causes a temporary drop in net profits. This occurs because withdrawing synthetic fertilizers and chemical pesticides causes an immediate drop in crop yields while the soil ecosystem recovers. Simultaneously, the crops cannot yet be sold at premium organic prices because they are still in the conversion phase.

115. (A) Transpiration Efficiency
Transpiration efficiency is an essential ecological metric in organic farming that quantifies how effectively a crop converts water lost through stomatal transpiration into dry harvestable biomass. Understanding this physiological parameter helps growers select drought-hardy cultivars and design sustainable irrigation regimes that conserve limited soil water resources while maintaining high crop yields.

116. (D) Biodynamic farming : Agriculture utilizing specific fermented preparations and cosmic rhythms
Biodynamic farming is a holistic agricultural methodology established by Rudolf Steiner. It treats the farm as a self-contained, living organism and coordinates farming activities with cosmic rhythms and astronomical cycles. The system relies on nine unique, highly fermented herbal, mineral, and manure preparations to restore biological vitality and enhance soil fertility.

117. (B) Both systems rely on complex synthetic herbicide rotations.
Organic and natural farming systems are distinct, but both strictly prohibit the use of synthetic chemical inputs, including herbicides, fertilizers, and pesticides. While organic farming permits external organic inputs like composts and involves mechanical weeding, natural farming focuses on zero external inputs and minimal soil disturbance. Neither system utilizes synthetic herbicide rotations.

118. (C) Seeds treated with synthetic fungicides are acceptable if washed thoroughly before planting.
Organic certification standards mandate that planting materials must be organically grown and entirely free from genetic modification. The use of seeds treated with synthetic chemical fungicides is strictly prohibited because washing them cannot guarantee complete removal of residues. If organic seeds are unavailable, untreated conventional seeds may be permitted with prior official approval.

119. (D) Growing the same crop variety organically and conventionally on the same holding
Parallel production refers to a specific scenario where a grower cultivates the exact same crop variety both organically and conventionally on the same farm. Because this practice poses

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139. (A) Using biological control and natural processes instead of chemical annihilation
In organic farming, the ethical concept of Ahinsa, or non-violence, is expressed through management practices that work with natural systems rather than trying to dominate them. Instead of using broad-spectrum synthetic chemical pesticides to eradicate pests, farmers utilize biological controls, companion planting, and natural plant defenses to maintain ecological balance.

140. (C) Frequent, small applications of compost to build structural retention
Sandy soils are prone to rapid leaching because they have high porosity and a low cation exchange capacity. To optimize Organic Nutrient Use Efficiency in these soils, farmers should apply small, frequent doses of organic compost. This practice gradually builds soil organic matter, improves structural water retention, and reduces nutrient losses.

141. (D) The Organic System Plan (OSP)
The Organic System Plan is the foundational document required for formal organic certification. It serves as a comprehensive operational blueprint where the farmer details the farm's baseline status, current management practices, input usage, soil conservation strategies, and measures to prevent contamination, ensuring total alignment with organic standards.

142. (C) Rice - Chickpea - Mungbean
Integrating grain legumes like chickpea and mungbean into a crop rotation with cereal crops like rice is an agronomically sound practice for maintaining soil nitrogen balance. Legumes form symbiotic relationships with nitrogen-fixing bacteria, which enriches the soil with nitrogen and reduces the need for external fertilizer inputs in subsequent crops.

143. (B) To act as a nutrient sink, windbreak, and source of mulching material
The forestry component in an Integrated Organic Farming System plays several ecological roles. These trees function as effective windbreaks to prevent wind erosion, capture deep soil nutrients to prevent leaching, and provide abundant organic mulch and green manure, which helps sustain soil biological health and moisture levels in adjacent cropped areas.

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144. (D) The volume of carbon dioxide released by soil microbial and root activity
Soil respiration is a direct physiological measurement of soil biological activity and overall health. It quantifies the volume of carbon dioxide gas released from the soil surface, which is produced by the metabolic activities of soil microbes, fungi, earthworms, and active plant roots as they break down organic matter.

145. (A) Nitrogen is lost as volatile ammonia gas, causing a foul odor.
A balanced carbon-to-nitrogen ratio is essential for successful composting. If the initial feedstock has a very low ratio, there is an excess of nitrogen relative to available carbon. Microorganisms decompose the material rapidly, but the excess nitrogen cannot be fully assimilated, resulting in its loss as volatile ammonia gas and causing foul odors.

146. (C) Castor cake
Castor cake is a concentrated organic manure derived as a byproduct of oil extraction from castor seeds. It is valued in organic agriculture for its high organic matter content and slow-release nitrogen characteristics. This slow decomposition rate ensures a steady, long-term supply of nutrients to the crop while improving soil structural properties.

147. (A) Gluconacetobacter diazotrophicus
Gluconacetobacter diazotrophicus is an endophytic, nitrogen-fixing bacterium that colonizes the internal tissues, stems, and roots of sugarcane. It forms a close symbiotic association with the plant, directly fixing atmospheric nitrogen inside the crop tissue. This biological process significantly reduces the requirement for external nitrogen inputs in sugarcane cultivation.

148. (D) Conversion of simple organic acids and alcohols into acetic acid and hydrogen
During anaerobic digestion in a biogas plant, the acetogenesis phase is a critical biochemical step. In this stage, acetogenic bacteria convert the simple organic acids, volatile fatty acids, and alcohols produced during acidogenesis into acetic acid, carbon dioxide, and hydrogen gas. These compounds serve as the direct substrates for methanogenic microbes.

miles. This practice connects local organic growers directly with nearby consumers, reducing fuel consumption, transportation emissions, and packaging waste.

92. (A) I and II
Organic farming systems manage pests through biological diversity and crop rotations, whereas conventional farming relies heavily on synthetic chemical insecticides. Additionally, conventional agriculture utilizes highly soluble mineral fertilizers for rapid plant nutrient absorption, while organic systems strictly prohibit both synthetic fertilizers and the cultivation of genetically modified crop varieties to maintain ecological health.

93. (A) Living ecological systems, working with them, emulating them, and helping sustain them
The IFOAM Principle of Ecology dictates that organic agriculture must be integrated within living ecological networks. This principle states that organic production should emulate natural ecosystems, work within local biological cycles, and sustain the soil, water, atmosphere, and biodiversity, rather than relying on artificial cultivation practices that disrupt natural ecological balances and species interactions.

94. (C) Sikkim
Sikkim is officially recognized as the world's first fully organic state. In January 2016, the Indian state achieved this milestone by implementing policy measures that prohibited the import, sale, and use of synthetic chemical fertilizers and pesticides, successfully transitioning all of its agricultural land to certified organic cultivation across the state.

95. (D) Date of the first inspection by the accredited certification body
The official start of the organic conversion period is determined by the date of the first physical inspection conducted by an accredited organic certification body. Verbal declarations or unregistered chemical-free management periods are not retroactively recognized. This official inspection establishes a clear regulatory baseline, initiating the mandatory time transition required for certification.

96. (C) Mixed cropping of grasses and legumes
To provide a continuous, high-quality forage supply for livestock in integrated systems, farmers practice the mixed cropping of grasses and leguminous crops. Grasses provide abundant energy and structural fiber, while legumes fix atmospheric nitrogen to offer highly digestible protein. This combined cultivation improves pasture productivity, balances the animal diet, and enhances soil organic fertility.

97. (B) Fish excreta provides nutrients, while their swimming movement aerates water and controls weeds.
Integrating aquaculture with flooded paddy rice cultivation yields highly significant biological benefits. The waste and excreta from swimming fish enrich the floodwater with nitrogen and phosphorus, acting as natural fertilizers. Concurrently, the movement of fish aerates the water column, disrupts weed seedling establishment, and helps control insect pests by directly consuming larvae.

98. (D) Active or labile carbon fraction
The active or labile carbon fraction is the portion of soil organic matter that serves as a highly accessible food and energy source for soil microorganisms. Unlike recalcitrant humus, this pool decomposes rapidly, fueling microbial metabolism, driving short term nutrient mineralization, and responding very rapidly to agronomic changes in organic soil management.

99. (C) 25:1 to 30:1
An initial carbon to nitrogen ratio between 25:1 and 30:1 is considered optimal for composting various organic wastes. This balanced ratio provides sufficient carbon to serve as an energy source for decomposing microbes, alongside adequate nitrogen for building essential microbial proteins, ensuring rapid decomposition without causing nitrogen immobilization or excessive ammonia volatilization.

100. (C) Neem cake
Neem cake is a highly effective concentrated organic manure obtained as a byproduct of oil extraction from neem seeds. It is unique because it supplies primary nutrients like nitrogen and phosphorus while containing active limonoids. These compounds act as natural nematicides, protecting crop root systems from plant parasitic nematodes in the soil.

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displayed on all certified organic food products sold in the domestic Indian market, assuring consumers that the food complies with national organic food safety standards.

159. (B) Stinging Nettle (Urtica dioica)
In biodynamic farming, preparation BD 504 is made using the stinging nettle plant. This plant is selected for its high iron and sulfur content, which plays a critical role in stabilizing nitrogen in compost piles. The preparation helps stimulate soil health, promotes decomposition, and aids in the formation of stable humus in the soil.

160. (D) Seed sovereignty, protecting the farmer's right to save and exchange seeds
Seed sovereignty is a fundamental ethical concept in organic agriculture. It protects the rights of farmers to save, breed, and exchange diverse open-pollinated seed varieties within their local communities. This practice reduces dependence on commercial, genetically modified seeds, preserves agricultural biodiversity, and empowers farmers economically and socially by fostering local self-reliance.

161. (A) $WUE = \dfrac{\text{Crop Yield}}{\text{Evapo transpiration}}$
Water Use Efficiency is a standard agronomic metric that quantifies how effectively a crop utilizes available water resources. It is mathematically defined as the ratio of crop yield to total evapotranspiration. This ratio helps growers assess water productivity, allowing them to optimize irrigation schedules and select drought-resistant cultivars in organic production.

162. (C) Natural farming systems
Masanobu Fukuoka pioneered natural farming systems, also known as "Do-Nothing" farming. This agricultural philosophy advocates for minimal human intervention in natural processes. The system is based on four key principles: zero tillage, zero chemical fertilizers or prepared compost, zero chemical pesticides or herbicides, and no weeding, allowing natural ecosystems to sustain crop growth.

163. (A) They harm soil biology and contradict ecological principles.
Synthetic herbicides are strictly prohibited in organic farming because they harm non-target soil biology, disrupt delicate soil ecosystems, and leave persistent chemical residues. Relying on synthetic chemical weed control contradicts the core ecological principles of organic agriculture, which prioritize the use of biological, cultural, and mechanical methods to manage weeds while preserving biodiversity.

164. (C) 36 months
Under standard organic certification guidelines, perennial crops, such as apple orchards, require a conversion period of thirty-six months before the harvested fruit can be certified as organic. This three-year transition period ensures that all synthetic chemical residues are cleared from the soil and allows natural biological processes to establish.

165. (B) Enhancing biodiversity for better soil resource use and pest buffering
Multiple cropping involves cultivating two or more crop species simultaneously on the same plot of land. In organic systems, this practice enhances ecological biodiversity, allowing plants to access soil resources at different depths. Additionally, it provides a natural buffer against pest outbreaks, reducing risks and maintaining stable overall yields.

166. (C) The livestock component
In an Integrated Organic Farming System, the livestock component acts as the primary nutrient transformer. Farm animals consume high-volume, low-nutrient crop residues, such as straw, and convert them into nutrient-rich manures and urine. This transformed material can be easily composted and applied back to fields, cycling nutrients through the farm.

167. (D) Improved cation exchange capacity and steady nitrogen release
Long-term organic soil management typically improves soil chemical health compared to conventional systems. Regular applications of organic composts, green manures, and cover crops increase soil organic matter, which enhances the soil's cation exchange capacity. This improvement allows for a steady release of essential plant nutrients while preventing environmental losses.

168. (A) Dry straw or sawdust
Carbon-rich materials, often referred to as "browns," are essential in composting to provide energy for microorganisms and build compost structure. Dry agricultural residues like straw, dry leaves, and sawdust are ideal carbon sources.

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Combining these materials with nitrogen-rich "greens" helps maintain a balanced carbon-to-nitrogen ratio, which is crucial for decomposition.

169. (B) Mesophilic → Thermophilic → Maturation
Composting proceeds through a sequence of three biological phases. It begins with the mesophilic phase, during which moderate-temperature microbes break down simple compounds. As microbial activity intensifies, temperatures rise, initiating the thermophilic phase, which sanitizes the compost by killing pathogens. Finally, the maturation phase stabilizes the organic matter into mature humus.

170. (B) Sesbania aculeata (Dhaincha)
Sesbania aculeata, commonly known as Dhaincha, is a highly resilient leguminous green manure crop. It is tolerant of waterlogged, saline, and alkaline soil conditions. Consequently, it is widely utilized in organic farming systems to reclaim degraded soils and supply substantial nitrogen and organic matter to subsequent wetland rice crops.

171. (A) Mycorrhiza (AMF)
Arbuscular Mycorrhizal Fungi form symbiotic associations with the roots of most crop plants. The fungal hyphae extend far into the soil, increasing the effective root surface area. This symbiosis allows the host plant to access and absorb slowly diffusing soil phosphorus and other micronutrients, improving crop nutrition in organic farming.

172. (C) Methane
Biogas is a renewable fuel mixture produced through the anaerobic digestion of organic matter. Its calorific value, or energy content, is determined by the concentration of methane gas, which typically makes up fifty to seventy percent of the total volume. Higher methane levels result in a more efficient fuel for heating and power generation.

173. (D) Jeevamrutha
Jeevamrutha is a fermented liquid organic formulation prepared from fresh cow dung, cow urine, pulse flour, jaggery, and forest soil. Fermented for forty-eight to seventy-two hours, this mixture serves as a powerful microbial culture. When applied, it inoculates the soil with beneficial microorganisms, accelerating nutrient cycling and promoting active plant growth.

174. (C) Formation of water-stable soil macro-aggregates
Earthworms improve soil structural health through their feeding and burrowing activities. As they ingest organic matter and mineral soil, their digestive processes combine these materials into cast excretions. These earthworm casts are rich in humic substances and microbial glues, which promote the formation of water-stable soil macro-aggregates, reducing soil erosion.

175. (B) It physically deprives emerging weed seedlings of light.
Mulching is a highly effective physical weed control technique in organic farming. By covering the soil surface with organic materials like straw, wood chips, or leaves, emerging weed seedlings are deprived of essential sunlight. Without access to light, these seedlings cannot photosynthesize, which suppresses their growth and prevents them from competing with crops.

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176. (D) Karanjin
Karanjin is a natural furanoflavonoid compound extracted from the seeds of the Pongam tree. It serves as an effective botanical pesticide in organic farming, particularly for managing soft-bodied insect pests like aphids and thrips. Karanjin acts as an insect growth regulator, feeding deterrent, and contact poison while remaining relatively safe for non-target organisms.

177. (A) Viral particles are highly sensitive to degradation by ultraviolet (UV) sunlight.
Nuclear Polyhedrosis Virus formulations are highly effective biological control agents for managing lepidopteran insect pests. However, the viral particles are highly sensitive to ultraviolet radiation from direct sunlight, which rapidly deactivates them. Spraying these biopesticides during the late evening hours ensures they remain active long enough to be ingested by pests.

178. (C) Organic produce has lower incidence of detectable synthetic pesticide residues.
Comparative food safety assessments show that organically grown produce consistently has a lower incidence of detectable synthetic chemical pesticide residues compared to conventionally grown crops. Because organic production standards strictly prohibit synthetic chemical crop protection inputs, consumers are provided with food that has a reduced risk of chemical contamination.

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179. (A) High humidity combined with poor ventilation
Storing organic potatoes requires careful environmental management because they are not treated with synthetic chemical sprout inhibitors or fungal treatments. High humidity combined with poor air ventilation creates an ideal environment for fungal and bacterial pathogens to multiply, leading to rapid rot, mold growth, and substantial post-harvest losses.

180. (D) Strictly prohibited at all production stages
The National Programme for Organic Production standards strictly prohibit the use of genetically engineered organisms, their derivatives, or genetically modified products at all stages of organic production. This exclusion applies to seeds, veterinary medicines, crop protection agents, and processing aids, ensuring the integrity of the organic supply chain.

181. (B) Non-Compliance
During an organic inspection, the acronym NC stands for Non-Compliance. An NC is issued when an inspector finds a practice, input, or record that does not conform to organic production standards. The producer must implement corrective actions to address the non-compliance within a specified timeframe to maintain organic certification.

182. (C) Food Safety and Standards Authority of India
To use the Jaivik Bharat logo on a processed organic food product in India, the product must comply with the organic food standards established by the Food Safety and Standards Authority of India. This national regulatory body oversees organic food quality, labeling, and import requirements, ensuring consumer confidence in certified organic foods.

183. (B) BD 502
Preparation BD 502 is a specialized biodynamic compost preparation. It is made by filling the bladder of a red stag with yarrow flowers, hanging it in the summer sun, and burying it in the soil during the winter. This preparation is used to regulate potassium, sulfur, and trace elements in compost piles.

184. (A) Providing living wages, safe conditions, and workers' rights
The ethical framework of organic farming includes the principle of fairness, which extends to agricultural labor. In practice, this principle requires providing agricultural workers with safe working conditions, fair living wages, and respect for their rights. Ensuring fair labor practices prevents exploitation and supports the social sustainability of organic farming communities.

185. (B) Nutrients are bound in complex organic molecules requiring microbial mineralization
During the initial transition to organic farming, Agronomic Nutrient Use Efficiency is often lower. This occurs because the nutrients in organic inputs are bound in complex organic molecules that are not immediately available to crops. They must undergo biological mineralization by soil microbes to be converted into plant-available forms.

186. (B) Principle of Care
The Principle of Care is one of the four foundational principles of organic agriculture established by IFOAM. It states that organic farming should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment, avoiding technologies with unpredictable consequences.

187. (A) Australia
Australia possesses the largest total area of certified organic agricultural land in the world, representing more than half of the global organic agricultural area. A significant portion of this certified land consists of extensive, low-input organic rangelands and pastoral properties used for livestock grazing rather than intensive crop cultivation.

188. (C) Producing organic and conventional crops of different varieties on one farm
Split production refers to a farming system where a single grower manages both organic and conventional production units on the same holding, but cultivates different crop varieties in each unit. This system requires strict physical separation and meticulous record-keeping to prevent cross-contamination and ensure the integrity of the organic certified products.

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209. (A) Microbial immobilization of nitrogen during breakdown of carbon-rich material
When fresh farmyard manure with high lignin and carbon content is applied to soil, soil microbes rapidly multiply to decompose the carbon-rich organic matter. To support their growth, these microorganisms absorb available mineral nitrogen from the soil, causing temporary microbial immobilization. This process temporarily reduces the nitrogen available for crop uptake.

210. (C) Organic farming promotes soil biodiversity and resilience, though yield gaps may occur.
Long-term comparative studies show that organic farming systems enhance soil biological health, promote soil biodiversity, and improve ecological resilience. Although organic systems can experience yield gaps compared to conventional systems, they reduce environmental pollution, improve soil structure, and support sustainable, long-term food production without chemical dependency.

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199. (D) They are relatively non-toxic to mammals and degrade rapidly under UV light.
Neem-derived pesticides are valued in organic farming because of their favorable environmental profile. The active compounds, including azadirachtin, are relatively non-toxic to mammals and beneficial insects. Additionally, they are highly biodegradable and break down rapidly when exposed to ultraviolet light in the field, preventing chemical accumulation in the environment.

200. (A) Soft-bodied insects like aphids
Chrysoperla carnea, commonly known as the green lacewing, is a widely used predatory insect in biological control programs. The larval stage is a voracious predator that feeds on a wide range of soft-bodied agricultural pests, including aphids, whiteflies, thrips, spider mites, and small caterpillars, helping to maintain ecological balance.

201. (B) The Cold Chain
The cold chain is a temperature-controlled supply chain that maintains perishable organic produce within a specific temperature range from the point of harvest to the final consumer. This process slows respiration, reduces moisture loss, and inhibits the growth of spoilage microorganisms, preserving product quality and extending post-harvest shelf life.

202. (B) The European Commission and Switzerland
The National Programme for Organic Production standards are officially recognized for equivalence by major international trading partners, including the European Commission and Switzerland. This mutual recognition ensures that organic agricultural products certified under NPOP can be exported to these countries without requiring additional on-site certification inspections.

203. (A) The high financial cost and complex documentation required
For small, resource-poor farmers selling to local markets, relying entirely on third-party certification is challenging. The main obstacles are the high financial costs of inspections and the complex, extensive record-keeping documentation required. These requirements present a significant barrier, making alternative models like the Participatory Guarantee System more suitable.

204. (C) Transaction Certificate
TraceNet is an internet-based system used to maintain traceability in India's organic export chain. To ensure accountability, the accredited certification body must issue a digital transaction certificate for each consignment of organic produce sold. This certificate contains detailed information about the product origin, quantity, and certification status.

205. (D) The farm is viewed as a single, self-sustaining living organism.
In biodynamic agriculture, founded by Rudolf Steiner, the core philosophy views the farm as a single, self-sustaining living organism. This concept emphasizes that all components of the farm, including crops, soil, livestock, and humans, are interconnected. The goal is to minimize external inputs by recycling nutrients internally to maintain ecological balance.

206. (C) By capturing a premium price from consumers for ecologically grown food
Organic farming aims to improve farmer profitability primarily through market differentiation and value creation. Because organic production standards prohibit synthetic inputs and require certification, organic food is marketed as a high-quality product. This allows farmers to capture a premium price from consumers who are willing to pay more for ecologically grown food.

207. (B) Calculating recovery fractions by comparing uptake in treated and control plots
To estimate the Organic Nutrient Use Efficiency of an applied compost over a single growing season, researchers calculate nutrient recovery fractions. This method involves comparing the total nutrient uptake in crops grown on compost-treated plots with the uptake in crops on untreated control plots, providing a clear measure of nutrient recovery.

208. (D) Maximizing yields through enhanced management of ecosystem services
Ecological intensification is a sustainable agricultural strategy that aims to maximize crop yields while minimizing environmental damage. Instead of relying on synthetic chemical inputs, this approach focuses on enhancing and managing natural ecosystem services, such as biological pest control, soil nutrient cycling, and insect pollination, to support crop production.

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189. (D) Intercropping
Intercropping is an intensive cropping system where two or more crop species are grown simultaneously in the same field. In organic farming, growing a subordinate crop between the rows of a primary crop helps maximize resource use, provides a physical canopy that suppresses weeds, reduces soil erosion, and improves overall yields.

190. (C) It requires complex management to synchronize diverse components and flows
Integrated Organic Farming Systems combine diverse components, such as crops, livestock, aquaculture, and agroforestry, to maximize nutrient cycling. A primary challenge of this system is the high level of management complexity required to balance and synchronize nutrient and energy flows among these diverse components, requiring significant planning and labor.

191. (B) Urease
Soil biological activity and health can be monitored by measuring soil enzymes. Urease is a critical soil enzyme that catalyzes the hydrolysis of urea into carbon dioxide and ammonia. Measuring urease activity helps assess the soil's nitrogen mineralization potential and provides valuable insights into soil microbial status under organic management.

192. (D) Biogas slurry
Biogas slurry is a valuable bulky organic manure produced as a byproduct of the anaerobic digestion of organic wastes, such as crop residues and animal manures, in a biogas plant. This process generates renewable methane gas while leaving a nutrient-rich slurry that contains nitrogen in a stable, readily available plant-soluble form.

193. (A) It improves soil crumb structure and moisture retention.
Applying concentrated oil cakes, such as neem or castor cake, to organic soils provides a source of plant nutrients. Beyond supplying nitrogen and other minerals, these organic cakes decompose to produce stable organic compounds. This process improves soil crumb structure, increases soil aggregation, and enhances moisture retention in the root zone.

194. (C) Frankia
Frankia is a genus of nitrogen-fixing actinomycete bacteria. Unlike Rhizobium, which associates with leguminous plants, Frankia forms symbiotic root nodules in actinorhizal plants, such as Casuarina and Alnus species. In organic agroforestry systems, Frankia helps improve soil nitrogen status and supports the establishment of windbreaks and buffer zones.

195. (A) The absolute exclusion of oxygen
In a floating-drum biogas plant, maintaining anaerobic conditions is essential for successful methanogenesis. Methanogenic archaea are obligate anaerobes, meaning the presence of oxygen is toxic to them and halts methane production. Therefore, the absolute exclusion of oxygen within the digester must be strictly maintained to ensure continuous biogas generation.

196. (D) It provides antimicrobial action protecting seeds from soil pathogens.
Beejamrutha is a traditional organic seed treatment formulation prepared from cow dung, cow urine, lime, and soil. The inclusion of cow urine provides natural antimicrobial and antifungal properties. When applied, this formulation coats the seeds, protecting them from soil-borne pathogens and seed-borne diseases during the critical germination phase.

197. (B) Earthworms
Earthworms are widely referred to as ecosystem engineers because of their profound physical influence on soil structure. By burrowing through soil profiles, they create channels that improve soil porosity and aeration. Simultaneously, they ingest organic matter and mineral soil, producing nutrient-rich casts that promote stable soil aggregates and enhance water infiltration.

198. (C) High-density planting to outcompete weeds
Agronomic weed management focuses on using cultural practices to suppress weeds rather than physical soil disturbance. High-density planting is a classic agronomic approach that increases crop plant populations per unit area. This practice promotes rapid crop canopy closure, which shades the soil surface and deprives emerging weeds of light, reducing weed competition.

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